The Electrochemical Society . . .

111th Meeting

WASHINGTON
May 12–16, 1957

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Washington Program

THE ELECTROCHEMICAL SOCIETY

One Hundred and Eleventh Meeting

—o—

Sunday through Thursday

May 12, 13, 14, 15, and 16, 1957

CONDENSED TECHNICAL PROGRAM

Corrosion — Electrothermics and Metallurgy (Abstracts 103–108) (Both sessions in South American Room)

Tuesday, May 14—9:00 A.M.–12:00 M.

Tuesday, May 14—2:00 P.M.–5:00 P.M.

Electric Insulation (Abstracts 1–21)

Monday, May 13—9:30 A.M.–11:30 A.M. (Congressional Room)

Monday, May 13—2:00 P.M.–5:00 P.M. (Congressional Room)

Tuesday, May 14—9:00 A.M.–11:30 A.M. (Pan American Room)

Tuesday, May 14—2:00 P.M.–4:30 P.M. (Pan American Room)

Wednesday, May 15—9:00 A.M.–12:00 M. (Pan American Room)

Wednesday evening, May 15—8:00 P.M.–10:15 P.M. (Pan American Room)

Electronics — Luminescence (Abstracts 22–54)

Tuesday, May 14—9:00 A.M.–11:50 A.M. (Congressional Room)

Tuesday, May 14—2:00 P.M.–5:00 P.M. (Congressional Room)

Wednesday, May 15—9:00 A.M.–12:00 M. (Congressional Room)

Wednesday, May 15—2:00 P.M.–4:00 P.M. (Federal Room)

Thursday, May 16—9:00 A.M.–12:00 M. (Congressional Room)

Thursday, May 16—2:00 P.M.–5:00 P.M. (Congressional Room)

Electronics — Semiconductors (Abstracts 55–73)

Tuesday, May 14—9:00 A.M.–11:45 A.M. (Presidential Ballroom)

Tuesday, May 14—2:30 P.M.–5:00 P.M. (Presidential Ballroom)

Wednesday, May 15—9:00 A.M.–12:00 M. (Presidential Ballroom)

Wednesday, May 15—2:00 P.M.–4:00 P.M. (Congressional Room)

Electronics — Thermionic Cathodes (Abstracts 74–85)

(All sessions in Ohio Room)

Wednesday evening, May 15—7:30 P.M.–10:15 P.M.

Thursday, May 16—9:00 A.M.–12:00 M.

Thursday, May 16—2:00 P.M.–5:00 P.M.

Electronics — Instrumentation (Abstracts 86–92)

(Both sessions in Pan American Room)

Thursday, May 16—9:00 A.M.–11:15 A.M.

Thursday, May 16—2:00 P.M.–3:30 P.M.

Electronics — Screen Application (Abstracts 93–97)

Thursday, May 16—2:00 P.M.–4:30 P.M. (Foyer No. 3)

Electrothermics and Metallurgy (Abstracts 98–102)

Monday, May 13—2:00 P.M.–4:30 P.M. (South American Room)

Electrothermics and Metallurgy—Corrosion (Abstracts 103–108)

Tuesday, May 14—9:00 A.M.–12:00 M. (South American Room)

Tuesday, May 14—2:00 P.M.–5:00 P.M. (South American Room)

Electrothermics and Metallurgy (Abstracts 109–129)

Wednesday, May 15—9:00 A.M.–11:30 A.M. (South American Room)

Wednesday evening, May 15—7:30 P.M.–9:55 P.M. (South American Room)

Thursday, May 16—9:00 A.M.–11:30 A.M. (South American Room)

Thursday, May 16—2:00 P.M.–4:30 P.M. (South American Room)

Industrial Electrolytic (Abstracts 130–137)

(Both sessions in Pan American Room)

Monday, May 13—9:30 A.M.–11:30 A.M.

Monday, May 13—2:00 P.M.–4:00 P.M.

Theoretical Electrochemistry—Joint Symposium with the National Science Foundation (Abstracts 138–190)

(All sessions in Federal Room)

Monday, May 13—9:30 A.M.–12:00 M.

Monday, May 13—2:00 P.M.–5:00 P.M.

Tuesday, May 14—9:00 A.M.–12:10 P.M.

Tuesday, May 14—2:00 P.M.–5:00 P.M.

Wednesday, May 15—9:00 A.M.–11:30 A.M.

Wednesday evening, May 15—7:30 P.M.–10-40 P.M.

Thursday, May 16—9:00 A.M.–11:45 A.M. General session.

Thursday, May 16—1:45 P.M.–4:45 P.M. General session.

GENERAL INFORMATION

Conventional Headquarters will be at the Hotel Statler, 16th St. at K&L Sts., N.W., Washington, D. C.

Rates per day for rooms (with bath) will be: single room $10.00, 11.00, 12.00, 13.00; double-bed room $15.00, 16.00; twin-bed room $15.00, 16.00, 17.00, 18.00, 20.00; suites for one or two $35.00 to $75.00.

Requests for room reservations at the Headquarters Hotel should be mailed to the Front Office Manager, Hotel Statler, 16th St. at K&L Sts., N.W., Washington 13, D. C.

Other hotels within two blocks of the Headquarters Hotel and their minimum rates are:

Ambassador, 14th & K Sts., N.W.—single $6.00, double $8.00, twin $10.00, parlor suite $14.00.

Hamilton, 14th & K Sts., N.W.—single $6.00, double $9.00, twin $10.50, parlor suite $25.00.

Lee House, 15th & L Sts., N.W.—single $7.75, double $11.25, twin $11.25, parlor suite $21.00.

Requests for room reservations should include mention of The Electrochemical Society.

The Office of the Secretary will be in the Michigan Room on the Mezzanine Floor.

All technical sessions will be held on the Mezzanine Floor.

Ladies' Headquarters will be in the New York Room on the Mezzanine Floor. For details, see program under Ladies' Program.

REGISTRATION

The registration desk will be in the upper lobby on the Mezzanine Floor. Following is the registration schedule:

Sunday, May 12—3:00 P.M. to 9:00 P.M.
Monday, May 13—8:00 A.M. to 5:00 P.M.
Tuesday, May 14—8:30 A.M. to 5:00 P.M.
Wednesday, May 15—8:30 A.M. to 5:00 P.M.
Thursday, May 16—8:30 A.M. to 12:00 M.

Registration fees are:

Members	$7.00
Ladies	$3.00
Nonmembers	$13.00
Students	$2.00

INFORMATION ABOUT WASHINGTON

As the Nation's Capital, Washington has many attractions which those attending the 111th Meeting of the Society will want to see. Three blocks from the Headquarters Hotel is the White House, flanked by the old Treasury and State Department buildings. Within walking distance of the White House is the Washington Monument, situated on the Mall, which is faced by the Lincoln Memorial on one end and the Capitol on the other. Congress will undoubtedly be in session and visitors may watch the proceedings of the Senate or the House of Representatives from the galleries. Famous historical shrines in the area include Mt. Vernon, Custis-Lee Mansion, Arlington Cemetery, and the Tomb of the Unknown Soldier.

While there are many monuments, parks, historical sights, and Government buildings, visitors may also want to visit the Smithsonian Institute, Folger Shakespearean Library, the National

Zoological Park, the National Gallery of Art, and the embassies and legations of the nations of the world.

Electrochemists will be interested in the Government research laboratories and the scientific installations in the area. Naval Research Lab., Naval Ordnance Lab., National Bureau of Standards, Naval Observatory, Geological Survey, Bureau of Mines, Dept. of Agriculture, and the National Institutes of Health have extensive research facilities in the area. In addition, there are the universities: Georgetown University, George Washington University, American University, Catholic University, and the University of Maryland and the Johns Hopkins University Applied Physics Lab., and, of course, the Headquarters of the American Chemical Society is just a short distance from the Hotel Statler.

Those working on Government research contracts may want to see where the money comes from. Congress, the Dept. of the Treasury, and its Bureau of Engraving and Printing play their part (not to mention taxpayers), but the Air Research and Development Command, the Atomic Energy Commission, the National Advisory Committee for Aeronautics, the Office of Naval Research, and the National Science Foundation make many of the contracts from their offices in Washington.

While attending the 1957 Spring Meeting of the Society, you will want to take advantage of the opportunity to go sight-seeing in the Nation's Capital, or to visit your colleagues in Washington in their laboratories, or to call on your contract sponsor.

SYMPOSIA

The Electric Insulation Division has scheduled symposia on: New Material Developments; Thermal Evaluation and Classification of Materials; Insulation Life; Prefabricated Circuitry; and a Panel Discussion on High Temperature Capacitors.

The Corrosion Division and Electrothermics and Metallurgy Division have scheduled a joint symposium on the Role of Metal and Oxide Structure in Oxidation and Corrosion.

The Electrothermics and Metallurgy Division has scheduled a symposium on Chemical Metallurgy, and

another Symposium on Columbium (Niobium).

The Industrial Electrolytic Division has scheduled one symposium on Fused Salt Electrolysis, and another on Chlor-Alkali Processes.

The Theoretical Electrochemistry Division and the National Science Foundation have scheduled a joint symposium of six sessions on the Structure of Electrolytic Solutions (Electrolytes); this symposium was made possible by the generous financial support of the National Science Foundation, Washington, D. C. The Division has also scheduled two general sessions.

GENERAL FUNCTIONS

Symposia Chairmen Breakfasts

On **Monday, Tuesday, and Wednesday**, May 13, 14, and 15, at 7:45 A.M., special breakfasts for all symposia chairmen will be held in the Ohio Room. On **Thursday**, May 16, the breakfast will be held in the California Room.

Monday Evening Mixer

On Monday, May 13, all those registered at the meeting are invited to attend the get-acquainted Mixer in the Presidential Ballroom from 8:00 to 11:00 P.M. Beer, soft drinks, potato chips, and pretzels will be served on a complimentary basis. A bar will be available for the purchase of mixed drinks.

Tuesday Luncheon and Annual Business Meeting

The Electrochemical Society Luncheon and Annual Business Meeting will be held Tuesday, May 14, at 12:15 P.M. in the Presidential Ballroom.

Tuesday Evening Reception and Banquet

A reception for President and Mrs. Hans Thurnauer will be held at 6:30 P.M. in the Federal Room. Cocktails will be served from 6:30 to 7:30 P.M., followed by dinner at 7:30 P.M. in the Congressional Room. President Thurnauer will deliver the Presidential Address.

Wednesday Electronics Division Cocktail Mixer

The Electronics Division will hold a Cocktail Mixer from 5:00 to 6:30 P.M.

on Wednesday, May 15, in the South American Room.

LABORATORY TRIPS

Three laboratory trips have been arranged for this meeting. Participation in these visits must be arranged for at the time of registration. Transportation tickets should be purchased at this time.

Monday, May 13, 1:45 P.M.—Citizens of the United States attending the meeting will be conducted on a tour of the U. S. Naval Research Lab. in Washington. The radioactive cobalt facilities, the van de Graff installation, and the nuclear reactor will comprise part of the tour. Also, the Electric Insulation Section where work on the thermal evaluation of dielectrics is being carried on will be shown. Finally, a visit to the Electrochemical Branch will be made to witness the work on batteries and gas detection. Transportation will be by chartered bus from the 16th St. entrance of the Hotel Statler ($1.00). The estimated time of return to the hotel is 5:00 P.M.

Tuesday, May 14, 12:15 P.M.—Citizens of the United States attending the meeting will be conducted on a tour of the U. S. Naval Ordnance Lab., White Oak in Silver Spring, Md. The guided tour will include visits to the Ordnance Environmental Lab., where experimental ordnance items are subjected to a variety of simulated conditions, such as shock, vibration, temperature and climate, and deep sea pressure; the Plastics and Battery Labs., and the Supersonic Wind Tunnels and Ballistic Ranges, where scale models are used in wide-range studies of the aerodynamic and physical problems encountered in extremely high speed flight. The visiting group will have lunch in the NOL cafeteria at the visitor's expense. Transportation will be by chartered bus from the 16th St. entrance of the Hotel Statler ($1.00). The estimated time of return to the hotel is 5:00 P.M.

Wednesday, May 15, 1:45 P.M.—A tour of the National Bureau of Standards has been arranged (attendance will be limited to 200). The tour will begin with a short address by Dr. Wallace R. Brode, Associate Director for Chemistry. Immediately following the address the guests will visit various active research projects at the Bureau. Trans-

portation will be by chartered bus from the 16th St. entrance of the Hotel Statler ($1.00). The estimated time of return to the hotel is 4:45 P.M.

LADIES' PROGRAM

Ladies' Headquarters will be in the New York Room throughout the meeting. A member of the Ladies' Committee will be in the Ladies' Headquarters on Sunday from 3:30 to 9:00 P.M. to welcome and assist the ladies in every way.

The temperature in Washington during May is usually in the 70°–80° range. The height of the azalea and rhododendron season is at this time of the year.

Monday morning, May 13—A get-together period with coffee will be held in the Ladies' Headquarters, starting at 9:30 A.M. (complimentary).

Monday afternoon, May 13—A luncheon and fashion show will be held at the Mayflower Hotel, starting at 1:00 P.M. The ladies will leave from the 16th St. entrance of the Hotel Statler at 12:30 P.M. and will return about 2:30 P.M. The remainder of the afternoon will be open for shopping or individual sight-seeing.

Monday evening, May 13—The ladies are invited to accompany their husbands to the Mixer at 8:00 P.M. (complimentary).

Tuesday morning and afternoon, May 14—Coffee will be served in the Ladies' Headquarters at 9:30 A.M. (complimentary). At 10:30 A.M. the ladies will meet at the 16th St. entrance of the hotel to board a bus for a tour of the Capitol and Supreme Court Buildings. Luncheon will be served at the well-known Hogate's Sea Food Restaurant. The bus will return to the hotel about 3:30 P.M.

Tuesday evening, May 14—The ladies are invited to attend the Reception and Banquet at 6:30 P.M.

Wednesday morning and afternoon, May 15—Coffee will be served in the Ladies' Headquarters at 9:30 A.M. (complimentary). At 10:15 A.M. the ladies will meet at the 16th St. entrance of the hotel to board the bus for a trip to historic Arlington Cemetery, Alexandria, and Mt. Vernon. Luncheon will be served en route and the bus will return to the hotel about 3:30 P.M.

Thursday morning, May 16—Coffee will be served at 9:30 A.M. in the Ladies' Headquarters (complimentary). This

morning and afternoon have been left open for informal tours. There is ample transportation by taxi, bus, or street car, and many points of interest are within walking distance of the Hotel Statler.

LUNCHEONS AND BUSINESS MEETINGS OF DIVISIONS

Electric Insulation Division Luncheon and Business Meeting, Monday, May 13, at 12:00 M. in the Congressional Room.

Electronics Division Luncheon and Business Meeting, Wednesday, May 15, at 12:30 P.M. in the South American Room.

Electrothermics and Metallurgy Division Luncheon and Business Meeting, Wednesday, May 15, at 12:30 M. in the Pan American Room.

Industrial Electrolytic Division Luncheon and Business Meeting, Monday, May 13, at 12:00 M. in the South American Room.

Theoretical Electrochemistry Division Luncheon, Wednesday, May 15, at 12:00 M. in the Federal Room honoring foreign speakers whose presence have been made possible by the joint sponsorship of the National Science Foundation; Business Meeting, Thursday, May 16, at 11:45 A.M. in the Federal Room.

BOARD AND COMMITTEE MEETINGS

Sunday, May 12, 2:00 P.M.—Meeting of the Board of Directors in the Pan American Room.

Monday, May 13, 4:30 P.M.—Meeting of the Council of Local Sections in the California Room.

Tuesday, May 14, 4:30 P.M.—Meeting of the Membership Committee in the California Room.

Wednesday, May 15, 4:00 P.M.—Meeting of the Editorial Staff of the Journal in the California Room.

Thursday, May 16, 12:00 M.—Meeting of General Chairmen of Future Meetings in the Michigan Room.

COST OF VARIOUS FUNCTIONS

(other than registration)

Symposia Chairmen Breakfasts	$2.50
Division Luncheons	$3.75
Society Luncheon	$3.75

Monday Evening Mixer Complimentary
Tuesday Reception and Banquet.. $7.50
Trip to U. S. Naval Research Lab. (transportation)..... $1.00
Trip to U. S. Naval Ordnance Lab. (transportation)..... $1.00
Trip to National Bureau of Standards (transportation)..... $1.00
Electronics Division Cocktail Mixer..... $2.50
Ladies' Functions
Monday—Fashion-Luncheon... $4.00
Tuesday—Capital Tour and Luncheon..... $4.50
Wednesday—Tour and Luncheon..... $5.00
(Book of three tickets.. $9.00)

(*The above prices include gratuities and taxes*)

JOURNALS

Copies of the February, March, April, and May issues of the JOURNAL of The Electrochemical Society will be available at the registration desk. The price of a single copy of the JOURNAL is $1.25 to members and $1.75 to nonmembers.

EXTENDED ABSTRACTS

The Electronics Division and Theoretical Electrochemistry Division are making available extended abstract booklets containing 1000-word abstracts of the papers presented at the Divisions' Washington symposia.

The Electronics Division booklet should be available by about April 15 from Martin F. Quaely, Research Dept., Lamp Div., Westinghouse Electric Corp., Bloomfield, N. J., at the price of $2.00 each.

The Theoretical Electrochemistry Division booklet can be obtained, probably before the meeting, from Dr. Ralph Roberts, 3308 Camalier Drive, Washington 15, D. C., at the price of $3.00 each.

Copies of both booklets will be on sale at the registration desk at the Washington Meeting.

DISCUSSION

There will be no recordings made of oral discussions. Those contributing to the discussion of a paper and desiring their remarks published will be supplied by the symposium chairman with a printed form on which any discussion

may be written. These forms should be given to the Secretary-Treasurer of the Division or to the Managing Editor of the JOURNAL after the session, or can be forwarded to the Managing Editor of the JOURNAL, 216 West 102nd St., New York 25, N. Y. The discussion will then be referred to the authors for reply. Publication of the discussion and the comments of the authors depends on publication of the article in the JOURNAL.

Written discussion should be submitted within two months following publication of any article in the JOURNAL.

A Discussion Section is published semiannually in the JOURNAL.

EMPLOYMENT POSTERS

Companies which desire to recruit employees at the Washington Meeting will have posters to this effect on a bulletin board near the registration desk.

Meeting	Monday		Tuesday		Wednesday			Thursday	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	Eve.	A.M.	P.M.
Corrosion—Electrothermics and Metallurgy			SA	SA					
Electric Insulation	C	C	PA	PA	PA		PA		
Electronics:									
Luminescence			C	C	C	F		C	C
Semiconductors			P	P	P	C			
Thermionic Cathodes							O	O	O
Instrumentation								PA	PA
Screen Application									N
Electrothermics and Metallurgy		SA	SA	SA	SA		SA	SA	SA
Industrial Electrolytic	PA	PA							
Theoretical Electrochemistry	F	F	F	F	F		F	F	F

SA = South American Room. PA = Pan American Room. O = Ohio Room.
C = Congressional Room. F = Federal Room. N = Foyer No. 3.
P = Presidential Ballroom.

Technical Program

Monday, May 13, 1957

9:00 A.M.—Formal Opening of the 111th Meeting with Introduction by General Chairman Fielding Ogburn and Response by President Hans Thurnauer (Federal Room).

NOTES

Address of author(s) is included with the abstract. In the Index to Authors, the abstract number is used instead of the page number.

Only two technical sessions, Electronics—Luminescence and Electronics—Semiconductors, are scheduled for the afternoon of Wednesday, May 15. Sessions that would normally be held at this time will be held Wednesday evening.

CORROSION—ELECTROTHERMICS AND METALLURGY

Joint Symposium

Tuesday, May 14, 1957

Role of Metal and Oxide Structure in Oxidation and Corrosion

(SOUTH AMERICAN ROOM)

9:00 A.M. and 2:00 P.M.—*See* Electrothermics and Metallurgy—Corrosion Program on p. 24, 55.

ELECTRIC INSULATION

Monday, May 13, 1957

New Material Developments with D. A. Lupfer presiding

(CONGRESSIONAL ROOM)

9:30 A.M.—**"Electric Moments of Certain Partially Fluorinated Esters"** by J. B. Romans and T. D. Callinan (Abstract No. 1)

10:00 A.M.—**"A New Dielectric Liquid for Impregnating Fixed Paper Capacitors"** by T. D. Callinan and J. B. Romans (Abstract No. 2)

10:30 A.M.—**"Progress Report on the Development of Metal Fiber Paper"** by H. F. Arledter (Abstract No. 3)

11:00 A.M.—"Electric Strength of Perchlorylfluoride (ClO_3F) Gas" by J. J. Chapman and L. J. Frisco (Abstract No. 4)

12:00 M.—Electric Insulation Division Luncheon and Business Meeting in the Congressional Room. Guest speaker, K. N. Mathes, General Electric Co., Schenectady, N. Y.

Electric Insulation (cont'd)

Monday, May 13, 1957

Panel Discussion
with D. A. Lupfer presiding

(CONGRESSIONAL ROOM)

2:00 P.M.—Panel Discussion of High Temperature Capacitors: K. H. Brandt, Convair, Pomona, Calif.; R. G. Breckenridge, National Carbon Co., Parma, Ohio; J. G. Breetlove, American Lava Corp., Chattanooga, Tenn.; J. M. Booe, P. R. Mallory & Co., Indianapolis, Ind.; C. E. Doyle, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio; J. F. Fabricius, Sprague Electric Co., North Adams, Mass.; R. S. Hower, Allen-Bradley Co., Milwaukee, Wis.; S. E. Rose, Avco Mfg. Co., Lawrence, Mass.; N. H. Terhune, Signal Corps Engineering Labs., Fort Monmouth, N. J.; H. T. Wensel, American Machine and Foundry, Alexandria, Va.

Electric Insulation (cont'd)

Tuesday, May 14, 1957

Thermal Evaluation and Classification of Materials with E. L. Brancato presiding

(PAN AMERICAN ROOM)

9:00 A.M.—"International Activities in the Evaluation of Electrical Insulation" by L. J. Berberich (Abstract No. 5)

9:30 A.M.—"Chemical Rate Phenomena in the Deterioration of Electrical Insulation" by T. W. Dakin (Abstract No. 6)

10:00 A.M.—"Principles for Classification of Insulating Materials" by K. N. Mathes (Abstract No. 7)

10:30 A.M.—"Thermal Evaluation of Electrical Insulating Materials" by J. F. Dexter (Abstract No. 8)

11:00 A.M.—"Thermal Stability of Laminated Thermosetting Plastics" by W. B. Kouwenhoven and G. G. Knickerbocker
(Abstract No. 9)

12:15 P.M.—Society Luncheon and Business Meeting in the Presidential Ballroom.

Electric Insulation (cont'd)

Tuesday, May 14, 1957

Insulation Life
with E. L. Brancato presiding

(PAN AMERICAN ROOM)

2:00 P.M.—"Statistical Methods Useful in Predicting Insulation Life" by W. E. Horton
(Abstract No. 10)

2:30 P.M.—"Application of Extreme Value Statistics on Breakdown Phenomena" by J. H. Davidson
(Abstract No. 11)

3:00 P.M.—"Derivation of Electronic Part-Failure Statistics from Material Properties" by J. A. Connor and D. I. Troxel
(Abstract No. 12)

3:30 P.M.—"Corona and Its Effect on Insulation—A Résumé" by T. W. Liao (Abstract No. 13)

4:00 P.M.—"Effects of High-Energy Gamma Radiation on Dielectric Solids" by P. H. Klein
(Abstract No. 14)

Electric Insulation (cont'd)

Wednesday, May 15, 1957

Prefabricated Circuitry
with C. E. Coy presiding

(PAN AMERICAN ROOM)

9:00 A.M.—"Some Aspects of Missile Package Design" by J. P. Morone
(Abstract No. 15)

9:45 A.M.—"Production of Prefabricated Circuitry" by M. F. Patrick
(Abstract No. 16)

10:30 A.M.—"Component Parts for Printed Wiring Assemblies" by H. C. Frankel and Wilbur Gross
(Abstract No. 17)

11:15 A.M.—"Application of Prefabricated Circuitry to Airborne Electronics Equipment" by G. B. Way and N. R. Dunbar
(Abstract No. 18)

Electric Insulation

Wednesday, May 15, 1957

Prefabricated Circuitry (cont'd)
with C. E. Coy presiding

(PAN AMERICAN ROOM)

8:00 P.M.—"Use of Shape as a Design Tool" by R. K. Jenny
(Abstract No. 19)

8:45 P.M.—"Quality Improvement in the Manufacture of Printed Wiring" by E. J. Lorenz
(Abstract No. 20)

9:30 P.M.—"An Approach for Meeting Future Needs of Electronic Components" by A. A. Lawson
(Abstract No. 21)

ELECTRONICS—LUMINESCENCE

Tuesday, May 14, 1957
with J. F. Waymouth presiding

(CONGRESSIONAL ROOM)

9:00 A.M.—Keynote Address—"Electroluminescent and Field Effects in Phosphors" by H. F. Ivey
(Abstract No. 22)

9:50 A.M.—"Effect of Electron Traps on the Brightness Waveform of Electroluminescent ZnS:Cu" by F. F. Morehead, Jr.
(Abstract No. 23)

10:20 A.M.—"Field Enhancement of X-Ray Excited Luminescence in ZnS·CdS:Mn(Au)" by Georges Destriau (Abstract No. 24)

10:50 A.M.—"Characteristics of Electroluminescence at Audio Frequencies" by R. M. Rulon and F. Koury (Abstract No. 25)

11:20 A.M. — "Electrocathodoluminescence" by P. M. Jaffe
(Abstract No. 26)

12:15 P.M.—Society Luncheon and Business Meeting in the Presidential Ballroom.

Electronics—Luminescence (cont'd)

Tuesday, May 14, 1957
with R. J. Ginther presiding

(CONGRESSIONAL ROOM)

2:00 P.M. — "AC Conductivity Measurements on CdS Crystals

under Various Types of Illumination" by S. Jaffe, H. Kallmann, B. Kramer, and G. M. Spruch (Abstract No. 27)

2:30 P.M.—"Action of Temperature on the X-Ray Electroenhancement Effect" by J. Mattler (Abstract No. 28)

3:00 P.M.—"Thin Film Phosphors" by L. R. Koller (Abstract No. 29)

3:30 P.M.—"Diffusion of Excitation in CdS Crystals" by H. Kallmann, B. Kramer, and A. Orenstein (Abstract No. 30)

4:00 P.M.—"Variations of the Fermi Level in ZnS Phosphors Contaminated with Iron Family Impurities" by N. Arpiarian (Abstract No. 31)

4:30 P.M. — "Investigations in $CuGaS_2$-ZnS and $AgGaS_2$-ZnS Systems" by E. F. Apple (Abstract No. 32)

Electronics — Luminescence (cont'd)

Wednesday, May 15, 1957
with H. C. Froelich presiding

(CONGRESSIONAL ROOM)

9:00 A.M.—"Energy Storage and Decay in Various Phosphors" by H. Kallmann and E. Sucov (Abstract No. 33)

9:30 A.M.—"Luminescence of 'Self-Coactivated' ZnS-Cu" by M. H. Aven and R. M. Potter (Abstract No. 34)

10:00 A.M.—"Process of Light Stimulation in ZnS Phosphors" by H. Kallmann, W. Schneider, and M. Sidran (Abstract No. 35)

10:30 A.M.—"Energy Transfer and Sensitization in Single-Crystal Phosphors" by R. Leach (Abstract No. 36)

11:00 A.M. — "Some Aspects of Quenching of Fluorescence in Organic Liquids" by M. Furst and H. Kallmann (Abstract No. 37)

11:30 A.M.—"Infrared Photography with the Help of Various Inorganic Phosphors" by H. Kallmann and J. Rennert (Abstract No. 38)

12:30 P.M.—Electronics Division Luncheon and Business Meeting in the South American Room.

Electronics—Luminescence (cont'd)

Wednesday, May 15, 1957
with L. Thorington presiding

(FEDERAL ROOM)

2:00 P.M. — "Time Constants of Alpha- and Electron-Produced Light Flashes" by G. Brucker and H. Kallmann (Abstract No. 39)

2:30 P.M.—"Resolution of Thermoluminescence Curves" by C. H. Haake (Abstract No. 40)

3:00 P.M.—"Potential Energy Curves for Phosphors" by K. H. Butler (Abstract No. 41)

3:30 P.M.—"A Review of the Measurement of the Quantum Efficiency of Inorganic Phosphors" by J. Tregellas-Williams (Abstract No. 42)

5:00 P.M. to 6:30 P.M.—Electronics Division Cocktail Mixer in the South American Room.

Electronics—Luminescence (cont'd)

Thursday, May 16, 1957
with A. H. McKeag presiding

(CONGRESSIONAL ROOM)

9:00 A.M.—"Temperature Characteristics of Phosphors for Use in High Pressure Mercury Vapor Lamps" by A. H. McKeag (Abstract No. 43)

9:30 A.M.—"Temperature Dependence of Fluorescence" by R. W. Mooney (Abstract No. 44)

10:00 A.M.—"Gray Discoloration in Calcium Halophosphates" by W. L. Wanmaker and M. G. A. Tak (Abstract No. 45)

10:30 A.M. — "Cerium-Activated Halophosphate Phosphors" by S. T. Henderson and P. W. Ranby (Abstract No. 46)

11:00 A.M.—"Luminescence of Tin-Activated Strontium Orthophosphate" by H. Koelmans and A. P. M. Cox (Abstract No. 47)

11:30 A.M.—"Zinc Modified Orthophosphate Phosphors" by M. J. B. Thomas and K. H. Butler (Abstract No. 48)

Thursday, May 16, 1957
with J. H. Schulman presiding

(CONGRESSIONAL ROOM)

2:00 P.M.—"Transition Probability Ratios in KCl:Tl and KCl:In" by F. E. Williams, P. D. Johnson, and B. Segall (Abstract No. 49)

2:30 P.M.—"Shape of the F-Band in KCl" by J. J. Markham and J. D. Konitzer (Abstract No. 50)

3:00 P.M.—"Interaction of Color Centers in the Alkali Halides" by W. D. Compton and John Lambe (Abstract No. 51)

3:30 P.M.—"Luminescence of Color Centers" by John Lambe and W. D. Compton (Abstract No. 52)

4:00 P.M.—"Experiments on Color Center Production in KI:Tl" by H. N. Hersh (Abstract No. 53)

4:30 P.M.—"Color Centers in Cadmium Fluoride" by M. Rubenstein and E. Banks (Abstract No. 54)

ELECTRONICS—SEMICONDUCTORS

Tuesday, May 14, 1957
with H. L. Goering presiding

(PRESIDENTIAL BALLROOM)

9:00 A.M.—Introductory Remarks by H. M. Pollack

9:10 A.M.—Keynote Address—"Compound Semiconductors" by D. A. Jenny (Abstract No. 55)

9:55 A.M.—"New Semiconductors" by J. H. Wernick and K. E. Benson (Abstract No. 56)

10:15 A.M.—"Carrier Transport Phenomena in Germanium Bicrystals" by H. F. Mataré and B. Reed (Abstract No. 57)

10:35 A.M.—"Photosensitivity of Ge Grain Boundaries" by O. Weinreich and H. F. Mataré (Abstract No. 58)

10:55 A.M.—"Growth and Definition of Bicrystals" by R. Wegener and H. F. Mataré (Abstract No. 59)

11:15 A.M.—"Dissociation Pressure and Cohesive Energy of Indium-Phosphide" by K. Weiser (Abstract No. 59A)

12:15 P.M.—Society Luncheon and Business Meeting in the Presidential Ballroom.

Electronics—Semiconductors (cont'd)

Tuesday, May 14, 1957
with W. Webster presiding

(PRESIDENTIAL BALLROOM)

2:30 P.M.—**"Impurity Diffusion in Germanium and Silicon"** by M. Tanenbaum (Invited Paper) (Abstract No. 60)

3:15 P.M.—**"Effects of Heat Treatment on Silicon Diffusion-Created Devices"** by C. Levi and I. Weiman (Abstract No. 61)

3:30 P.M.—**"Oxygen as an Impurity in Transistor Grade Silicon"** by W. Kaiser and P. H. Keck (Abstract No. 62)

4:00 P.M.—**"Ternary Distribution Coefficients in Silicon"** by David Navon (Abstract No. 63)

4:20 P.M.—**"Evaporation and Alloying of Metals to Silicon"** by J. M. Goldey, M. Tanenbaum, and N. Holonyak, Jr. (Abstract No. 64)

4:40 P.M.—"Recent News" Papers. Titles and short abstracts will be available at the Registration Desk.

Electronics—Semiconductors
(cont'd)

Wednesday, May 15, 1957
with W. Dills presiding

(PRESIDENTIAL BALLROOM)

9:00 A.M.—**"Transistor-Grade Silicon, I. Preparation of Ultrapure Silicon Tetraiodide"** by Bernard Rubin, G. H. Moates, and J. R. Weiner (Abstract No. 65)

9:20 A.M.—**"Transistor-Grade Silicon, II. Zone Purification of Silicon Tetraiodide"** by G. H. Moates and Bernard Rubin (Abstract No. 66)

9:40 A.M.—Paper withdrawn. (Abstract No. 67)

10:10 A.M.—**"Contribution to the Floating Zone Technique for Refining Silicon"** by E. Buehler (Abstract No. 68)

10:35 A.M.—**"Heat Treatment of Silicon Using Zone Heating Techniques"** by H. C. Theuerer, J. M. Whelan, H. E. Bridgers, and E. Buehler (Abstract No. 69)

11:00 A.M.—"Recent News" Papers. Titles and short abstracts will be available at the Registration Desk.

12:30 P.M.—Electronics Division Luncheon and Business Meeting in the South American Room.

Electronics — Semiconductors
(cont'd)

Wednesday, May 15, 1957
with B. J. Rothlein presiding

(CONGRESSIONAL ROOM)

2:00 P.M.—**"Optical Measurement of Film Growth on Silicon and Germanium Surfaces in Room Air"** by R. J. Archer (Abstract No. 70)

2:25 P.M.—**"Bonding Material for Making Contact to Etched *P*-Type Silicon"** by D. R. Mason and J. C. Sarace (Abstract No. 71)

2:45 P.M.—**"Description of Electrochemical Jet Etching of Silicon"** by Albert Mark (Abstract No. 72)

3:15 P.M.—**"Mechanism of Electrolytic Rectification"** by P. F. Schmidt (Abstract No. 73)

3:35 P.M.—"Recent News" Papers. Titles and short abstracts will be available at the Registration Desk.

5:00 P. M. to 6:30 P.M.—Electronics Division Cocktail Mixer in the South American Room.

ELECTRONICS—THERMIONIC CATHODES

Wednesday, May 15, 1957
with R. C. Hughes presiding

(OHIO ROOM)

7:30 P.M.—**Introductory Remarks** by R. H. Plumlee

7:35 P.M.—**Keynote Address—"Recent Work on Surface Properties of Oxide Semiconductors"** by J. J. Lander (Abstract No. 74)

8:15 P.M.—**"Thermionic Emission Characteristics of Thoriated Rhenium"** by W. E. Nexsen, Jr., and G. B. Gaines (Abstract No. 75)

8:45 P.M. — "Thermionics and Evaporation Properties of Some Lanthanide Oxides" by D. L. Schaefer (Abstract No. 76)

9:15 P.M.—**"Emission from Barium on Tantalum Carbide"** by J. E. White (Abstract No. 77)

9:45 P.M.—"Preparation and Properties of the Magnesium Oxide Cold Cathode" by Dietrich Dobischek (Abstract No. 78)

Electronics—Thermionic Cathodes
(cont'd)

Thursday, May 16, 1957
with S. Wagener presiding

(OHIO ROOM)

9:00 A.M.—"Reactions of Oxide Cathodes with Gases at Low Pressures" by R. J. Ruka and E. A. Gulbransen (Abstract No. 79)

9:30 A.M.—"The Electron Microscopy of Alkaline Earth Carbonates" by C. F. Tufts (Abstract No. 80)

10:00 A.M.—"Relationship between Thermal Decomposition in Vacuum and Macrostructure of Alkaline Earth Carbonates" by B. Wolk and J. G. Buck (Abstract No. 81)

10:30 A.M.—"Study of Interface Impedance Characteristics of Seven Commercial Cathode Nickel Alloys" by C. D. Richard, Jr., and A. M. Bounds (Abstract No. 82)

11:00 A.M.—"Considerations of Oxide Cathode Interface Impedance" by A. P. Haase, R. E. Holmes, and F. J. Schmidt (Abstract No. 83)

11:30 A.M.—"A Study of the Molded Nickel Cathode" by C. P. Hadley, W. G. Rudy, and A. J. Stoeckert (Abstract No. 84)

Electronics—Thermionic Cathodes
(cont'd)

Thursday, May 16, 1957
with J. E. White presiding

(OHIO ROOM)

2:00 P.M.—"New Developments in the L-Cathode" by C. A. M. van den Broek and A. Venema (Abstract No. 85)

2:30 P.M.—Unscheduled Reports on Recent Developments.

3:00 P.M.—Round-Table Discussion. The purpose of this round table is to promote an entirely unrestricted exchange of ideas between the audience and a panel of active workers in the field. Controversial subjects will be welcomed for discussion. Members of the audience may be called on for comments on the discussion.

ELECTRONICS—INSTRUMENTATION

Thursday, May 16, 1957
with A. E. Martin presiding

(PAN AMERICAN ROOM)

9:00 A.M.—"Equipment for the Autographic Determination of the Electrical Resistance of Metals at High Temperatures" by G. A. Moore (Abstract No. 86)

9:40 A.M.—"Methods of Measuring High Resistances" by E. F. Turner, Jr. (Abstract No. 87)

10:10 A.M.—"Calibration of Kinescope Test Sets for Color Balance and Light Output" by G. P. Kirkpatrick and A. E. Hardy (Abstract No. 88)

10:40 A.M.—"Interferometric Calibration of Kinescope Aluminum Film Thickness Meters" by G. P. Kirkpatrick and T. A. Saulnier (Abstract No. 89)

Electronics—Instrumentation
(cont'd)

Thursday, May 16, 1957
with A. E. Martin presiding

(PAN AMERICAN ROOM)

2:00 P.M.—"An Apparatus for Vacuum and Atmospheric Differential Thermal Analysis" by J. G. Rabatin and C. S. Card (Abstract No. 90)

2:30 P.M.—"Application of Lead Sulfide Detector to the Study of Luminescence in the Near Infrared Region" by J. M. Goldstein, W. M. McNabb, and J. F. Hazel (Abstract No. 91)

3:00 P.M.—"Effect of Current Drains on Cadmium Standard Cells" by G. D. Vincent (Abstract No. 92)

ELECTRONICS—SCREEN APPLICATIONS

Thursday, May 16, 1957
with M. Sadowsky presiding

(FOYER NO. 3)

2:00 P.M.—"Wet and Dry Strengths of Cathode Ray Screens" by R. W. Spencer, N. W. McCready, and Wm. Stericker (Abstract No. 93)

2:30 P.M.—"Sedimentation Volumes of a Phosphor Powder in Potassium Silicate and Potassium Silicate-Barium Acetate Settling Media" by J. F. Hazel and Louis Fiorito (Abstract No. 94)

3:00 P.M.—"Surface Phenomena Associated with the Application of Organic Films to Phosphor Screens" by R. W. Dudding (Abstract No. 95)

3:30 P.M.—"Photodeposition of Luminescent Screens" by M. Sadowsky and D. Payne, Jr. (Abstract No. 96)

4:00 P.M.—"Phosphor Slurry Process for Color-Kinescope Screening" by D. J. Donahue and T. A. Saulnier (Abstract No. 97)

ELECTROTHERMICS AND METALLURGY

Monday, May 13, 1957

Chemical Metallurgy
with John Blocher presiding

(SOUTH AMERICAN ROOM)

2:00 P.M.—"High Temperature Oxidation of High Purity Nickel between 750° and 1050°C" by E. A. Gulbransen and K. F. Andrew (Abstract No. 98)

2:30 P.M.—"Ten-Gram Levitation Melted Ingots" by G. Comenetz and J. W. Salatka (Abstract No. 99)

3:00 P.M.—"Growth of Whiskers by Reduction of Halogenides" by H. Wiedersich (Abstract No. 100)

3:30 P.M.—"Zone Melting of Uranium" by C. I. Whitman, V. Compton, and R. B. Holden (Abstract No. 101)

4:00 P.M.—"Molybdenum Plating inside of Large Bore Tubes" by P. L. Raymond (Abstract No. 102)

ELECTROTHERMICS AND METALLURGY—CORROSION

Joint Symposium

Tuesday, May 14, 1957

Role of Metal and Oxide Structure in Oxidation and Corrosion
with W. E. Tragert presiding

(SOUTH AMERICAN ROOM)

9:00 A.M.—"Influence of Crystal Face on Some Electrochemical Properties of Single Crystals of Copper" by A. T. Gwathmey (Abstract No. 103)

10:00 A.M.—"Structural and Chemical Factors Associated with the Fracture of Metals" by W. D. Robertson (Abstract No. 104)

11:00 A.M.—"Influence of Structural Factors on the Corrosion of Stainless Steel" by N. A. Nielsen and M. A. Streicher (Abstract No. 105)

12:15 P.M.—Society Luncheon and Business Meeting in the Presidential Ballroom.

Electrothermics and Metallurgy—Corrosion (cont'd)

Joint Symposium (cont'd)

Tuesday, May 14, 1957

Role of Metal and Oxide Structure in Oxidation and Corrosion with D. A. Vermilyea presiding

(SOUTH AMERICAN ROOM)

2:00 P.M.—"Role of Metal and Oxide Structures in High Temperature Oxidation Processes" by C. E. Birchenall (Abstract No. 106)

3:00 P.M.—"Effect of Dislocations in Oxide Films on Oxidation" by N. Cabrera (Abstract No. 107)

4:00 P.M.—"Interaction of Oxide and Metal Crystal Structures" by J. T. Waber (Abstract No. 108)

Electrothermics and Metallurgy (cont'd)

Wednesday, May 15, 1957

Symposium on Columbium (Niobium) with Bruce Gonser presiding

(SOUTH AMERICAN ROOM)

9:00 A.M.—Introductory Remarks by Bruce Gonser.

9:05 A.M.—"The Element Columbium and Its Compounds" by J. R. Darnell and L. F. Yntema (Abstract No. 109)

9:35 A.M.—"Supplies of Columbium" by K. B. Higbie (Abstract No. 110)

10:00 A.M.—"Some Sources and Production Statistics for Columbium" by H. P. Croft (Abstract No. 111)

10:30 A.M.—"Economic Aspects and Supply Situation for Columbium" by R. L. Carmichael (Abstract No. 112)

11:00 A.M.—"A Review of the Extractive Metallurgy of Niobium" by M. E. Sibert, A. J. Kolk, and M. A. Steinberg (Abstract No. 113)

12:30 M.—Electrothermics and Metallurgy Division Luncheon and Business Meeting in the Pan American Room.

Electrothermics and Metallurgy (cont'd)

Wednesday, May 15, 1957

Symposium on Columbium (Niobium) (cont'd)
with E. M. Sherwood presiding

(SOUTH AMERICAN ROOM)

7:30 P.M.—"Informal Comments on the ONR Program of Basic Research on Columbium" by N. E. Promisel (Abstract No. 114)

7:45 P.M.—"Separation of Ta and Nb" by J. L. Tews and S. L. May (Abstract No. 115)

8:15 P.M.—"Preparation and Properties of High Purity Tantalum and Columbium" by R. C. Bourke, J. M. Blocher, Jr., and I. E. Campbell (Abstract No. 116)

8:45 P.M.—"Preparation of High Purity, Ductile Niobium by Fusion Electrolysis" by A. J. Kolk, M. E. Sibert, and M. A. Steinberg (Abstract No. 117)

9:15 P.M.—"Analysis of Certain Metallic Impurities in Niobium" by J. F. Reed and A. H. Wolfe (Abstract No. 118)

9:35 P.M.—"Analysis of Oxygen and Nitrogen in Niobium" by W. Harris (Abstract No. 119)

Electrothermics and Metallurgy (cont'd)

Thursday, May 16, 1957

Symposium on Columbium (Niobium) (cont'd)
with A. U. Seybolt presiding

(SOUTH AMERICAN ROOM)

9:00 A.M.—"Hydrogen and Niobium—Reaction and Diffusion Kinetics" by M. W. Mallett and W. M. Albrecht (Abstract No. 120)

9:30 A.M.—"Tensile Properties of Niobium on the Basis of Purity and Prior Stress History" by F. J. Anders, Jr., and W. I. Pollock (Abstract No. 121)

10:00 A.M.—"Ductile - to - Brittle Transition in Niobium" by E. T. Wessel and D. D. Lawthers (Abstract No. 122)

10:30 A.M.—"Effect of Rare Earth Additions on the Ductility of Arc Melted Group V-A Metals" by J. W. Semmel, Jr. (Abstract No. 123)

11:00 A.M.—"Electroplating on Columbium" by J. G. Beach (Abstract No. 124)

Electrothermics and Metallurgy
(cont'd)

Thursday, May 16, 1957

Symposium on Columbium (Niobium) (cont'd)
with E. M. Mahla presiding

(SOUTH AMERICAN ROOM)

2:00 P.M.—"Oxidation of Niobium between 375° and 700°C" by E. A. Gulbransen and K. F. Andrew (Abstract No. 125)

2:30 P.M.—"Development of Oxidation-Resistant Niobium Alloys" by H. T. Kling (Abstract No. 126)

3:00 P.M.—"Effect of Alloy Additions on the Oxidation Resistance of Niobium" by F. J. Clauss and C. A. Barrett (Abstract No. 127)

3:30 P.M.—"Oxidation of Niobium-Chromium Alloys at Elevated Temperatures" by C. A. Barrett and F. J. Clauss (Abstract No. 128)

4:00 P.M.—"Vacuum Reactions of Niobium during Sintering" by W. D. Klopp, C. T. Sims, and R. I. Jaffee (Abstract No. 129)

INDUSTRIAL ELECTROLYTIC

Monday, May 13, 1957

Fused Salt Electrolysis
with M. Janes presiding

(PAN AMERICAN ROOM)

9:30 A.M.—"Electromagnetic Forces in a Large Aluminum Furnace" by O. Chr. Böckman and J. Wleügel (Abstract No. 130)

10:00 A.M.—"Electrical Conductivity of Molten Fluorides, I. Apparatus and Method" by E. W. Yim and Morris Feinleib
(Abstract No. 131)

10:30 A.M.—"Electrical Conductivity of Molten Fluorides, II. Conductance of Alkali Fluorides, Cryolites, and Cryolite-Base Melts" by E. W. Yim and Morris Feinleib (Abstract No. 132)

11:00 A.M.—"Uranium Metal Preparation by Electrolytic Reduction of Its Oxides" by L. W. Niedrach and B. E. Dearing
(Abstract No. 133)

12:00 M.—Industrial Electrolytic Division Luncheon and Business Meeting in the South American Room. J. C. Cole will give the Chlor-Alkali Committee Report.
(Abstract No. 134)

Industrial Electrolytic (cont'd)

Monday, May 13, 1957

Chlor-Alkali Processes
with J. C. Cole presiding

(PAN AMERICAN ROOM)

2:00 P.M.—"Influence of Impurities in the Electrolyte in Chlorine-Caustic Electrolysis by the Mercury Cell Process, VI. Investigation of the Influence of Graphite Particles on Amalgam Decomposition and Cathodic Current Efficiency" by Gösta Angel, Rolf Brännland, and Stig Dahlerus
(Abstract No. 135)

2:30 P.M.—"The Castner-Kellner Shunt Circuit for Mercury Chlor-Alkali Cells" by M. Janes
(Abstract No. 136)

3:00 P.M.—"Electrolytic Production of Sodium Perchlorate Using Lead Dioxide Anodes" by J. C. Schumacher, D. R. Stern, and P. R. Graham
(Abstract No. 137)

THEORETICAL ELECTRO-CHEMISTRY

Monday, May 13, 1957

Joint Symposium

Structure of Electrolytic Solutions (Electrolytes)

Sponsored by the National Science Foundation and the ECS with W. J. Hamer presiding

(FEDERAL ROOM)

9:30 A.M.—Introductory Remarks by W. J. Hamer

9:35 A.M.—"Interpretation of Activity and Osmotic Coefficients" by George Scatchard
(Abstract No. 138)

10:05 A.M.—"Electrolytic Solution Problem in Statistical Mechanics" by J. E. Mayer
(Abstract No. 139)

10:35 A.M.—"Successes and Limitations of the Theory of Debye and Hückel" by E. A. Guggenheim
(Abstract No. 140)

11:05 A.M.—"Statistical Mechanical Theory of Plasmas and Liquid Metals" by J. G. Kirkwood
(Abstract No. 141)

11:35 A.M.—"Properties of Concentrated Solutions of Acids and Alkalies" by R. P. Bell
(Abstract No. 142)

Theoretical Electrochemistry
(cont'd)

Monday, May 13, 1957

Joint Symposium

Structure of Electrolytic Solutions (Electrolytes) (cont'd)

Sponsored by the National Science Foundation and the ECS with E. Yeager presiding

(FEDERAL ROOM)

1:45 P.M.—"Present State of the Electrolyte Problem" by C. A. Kraus (Abstract No. 142A)

2:00 P.M.—"Properties of Rare Earth Salts in Electrolytic Solutions" by F. H. Spedding and Gordon Atkinson (Abstract No. 143)

2:30 P.M.—"Nuclear Magnetic Resonance Studies of Aqueous Solutions" by H. S. Gutowsky (Abstract No. 144)

3:00 P.M.—"Raman Spectral Studies of Ionic Equilibria in Solutions of Strong Electrolytes" by T. F. Young (Abstract No. 145)

3:30 P.M.—"Melting Mechanisms of Ionic Crystals" by A. R. Ubbelohde (Abstract No. 146)

4:00 P.M.—"Influence of Complex Ions on Structure and Reactivity of Fused Salts" by E. R. Van Artsdalen (Abstract No. 147)

4:30 P.M.—"A Point of View on Ion Clouds; A Suggested Explanation of an Activity Anomaly in Dilute Aqueous LiCl Solutions" by H. S. Frank and P. T. Thompson (Abstract No. 148)

Theoretical Electrochemistry
(cont'd)

Tuesday, May 14, 1957

Joint Symposium

Structure of Electrolytic Solutions (Electrolytes) (cont'd)

Sponsored by the National Science Foundation and the ECS with Ralph Roberts presiding

(FEDERAL ROOM)

9:00 A.M.—"Incomplete Dissociation in Aqueous Salt Solutions" by C. W. Davies (Abstract No. 149)

9:30 A.M.—"Hydration and Association in Aqueous Electrolyte Solutions" by E. Glueckauf (Abstract No. 150)

10:00 A.M.—"Hydrogen Bond Structures, Hydration of Protons, and Proton Transfer in Aqueous Solutions" by M. Eigen (Abstract No. 151)

10:30 A.M.—"Quantitative Measurements of Ionic Vibration Potentials" by E. Yeager, J. Booker, and F. Hovorka (Abstract No. 152)

10:55 A.M.—"A Physical Theory of Ion Solvation" by M. Balkanski (Abstract No. 153)

11:20 A.M.—"Aquo-ions and Ion Pairs" by J. F. Duncan and D. L. Kepert (Abstract No. 154)

11:50 A.M.—"Ionization of the Bisulfate Ion; Notes on the Electromotive Force Method of Determining Ionization Constants" by W. J. Hamer (Abstract No. 155)

12:15 P.M.—Society Luncheon and Business Meeting in the Presidential Ballroom.

Theoretical Electrochemistry
(cont'd)

Tuesday, May 14, 1957

Joint Symposium

Structure of Electrolytic Solutions (Electrolytes) (cont'd)

Sponsored by the National Science Foundation and the ECS with Ernest Yeager presiding

(FEDERAL ROOM)

2:00 P.M.—"Heats of Dilution of Very Dilute Solutions of Weak and Strong Electrolytes" by E. Lange (Abstract No. 156)

2:30 P.M.—"Anion Exchange Studies of Metal Complexes" by K. A. Kraus (Abstract No. 157)

3:00 P.M.—"Electrophoresis and Conductivity in Solutions Containing Polyelectrolytes" by J. J. Hermans (Abstract No. 158)

3:30 P.M.—"Normal and Abnormal Ionic Mobilities in Anhydrous Hydrofluoric Acid and Hydrogen Peroxide-Water Systems" by Martin Kilpatrick (Abstract No. 159)

4:00 P.M.—"Mobilities of Ions and Uncharged Molecules in Solutions in Relation to Viscosity" by R. H. Stokes (Abstract No. 160)

4:30 P.M.—"Conductance Equations of Robinson-Stokes and Wishaw-Stokes Applied to the Regions of Dilute and of Concentrated Solutions, Respectively" by A. N. Campbell (Abstract No. 161)

Theoretical Electrochemistry
(cont'd)

Wednesday, May 15, 1957

Joint Symposium

Structure of Electrolytic Solutions (Electrolytes) (cont'd)

Sponsored by the National Science Foundation and the ECS with Ralph Roberts presiding

(FEDERAL ROOM)

9:00 A.M.—**"A Redetermination of the Value of the Faraday with the Iodine Coulometer"** by D. A. MacInnes and A. R. Pray (Abstract No. 162)

9:30 A.M.—**"Diffusion and Activity Coefficients of Electrolytes in Dilute Aqueous Solutions"** by H. S. Harned (Abstract No. 163)

10:00 A.M.—**"Thermal Diffusion and Related Effects in Solutions of Electrolytes"** by J. N. Agar (Abstract No. 164)

10:30 A.M.—**"Temperature Dependence of the Thermal Diffusion of Aqueous KCl"** by L. G. Longsworth (Abstract No. 165)

11:00 A.M.—**"Data for the Concentration Dependence of the Four Diffusion Coefficients of the System NaCl-KCl-H_2O at 25°"** by I. J. O'Donnell and L. J. Gosting (Abstract No. 166)

12:00 M.—Theoretical Division Luncheon honoring foreign speakers of the symposium whose presence have been made possible by the joint sponsorship of the National Science Foundation, in the Federal Room. Professor Peter Debye, Cornell University, speaker.

Theoretical Electrochemistry
(cont'd)

Wednesday, May 15, 1957

Joint Symposium

Structure of Electrolytic Solutions (Electrolytes) (cont'd)

Sponsored by the National Science Foundation and the ECS with W. J. Hamer presiding

(FEDERAL ROOM)

7:30 P.M.—**"Thermodynamic Functions of Single Ionic Species in**

Solutions" by Pierre Van Rysselberghe (Abstract No. 167)

8:00 P.M.—"Some Thermodynamic Properties of Solutions of Salts of Bivalent Metals" by J. M. Austin, R. A. Matheson, and H. N. Parton (Abstract No. 168)

8:30 P.M.—"Ionization Constants of Weak Acids from Spectrophotometric Measurements" by R. A. Robinson (Abstract No. 169)

9:00 P.M.—"Conductance and *p*H Measurements in Methanol-Water Mixtures" by Theodore Shedlovsky (Abstract No. 170)

9:25 P.M.—"Ionization Equilibria in Ammonia-Water Solutions from 5° to 55° as Obtained from High Field Conductance Measurements" by Emil Arnold, Harlow Freitag, and Andrew Patterson, Jr. (Abstract No. 171)

9:50 P.M.—"An Isopiestic Unit for High Temperature Studies" by B. A. Soldano, R. J. Fox, and R. W. Stoughton (Abstract No. 172)

10:15 P.M.—"Thermodynamics of Hydrogen Chloride in Ethyl Alcohol from EMF Measurements" by G. J. Janz and Harry Taniguchi (Abstract No. 173)

Theoretical Electrochemistry
(cont'd)

Thursday, May 16, 1957

General Session
with E. Yeager presiding

(FEDERAL ROOM)

9:00 A.M.—"Kinetics of Bromoacetate-Thiosulfate Ionic Reaction" by Gerald Corsaro and H. L. Stephens (Abstract No. 174)

9:20 A.M.—"Zinc Standard Potential in Water-Organic Mixtures" by Gerald Corsaro and H. L. Stephens (Abstract No. 175)

9:40 A.M.—"Uncommon Valency Ions and the Difference Effect" by M. E. Straumanis (Abstract No. 176)

10:00 A.M.—"Streaming Potentials in Spherical-Grain Sands" by C. E. Bleil and Wm. Schriever (Abstract No. 177)

10:20 A.M.—"EDL Capacities at Solid Metal-Solution Interfaces" by J. J. McMullen and Norman Hackerman (Abstract No. 178)

10:40 A.M.—"Impedance at Polarized Platinum Electrodes in Various Electrolytes" by J. N. Sarmousakis and M. J. Prager (Abstract No. 179)

11:00 A.M.—"Catalytic Activity and Electronic Structure" by Sigmund Schuldiner and J. P. Hoare (Abstract No. 180)

11:20 A.M.—"Mechanism of Hydrogen Producing Reactions on Palladium, IV. Electrochemical Kinetics on the α-Palladium-Hydrogen System in Acid Solutions" by J. P. Hoare and Sigmund Schuldiner (Abstract No. 181)

11:45 A.M.—Theoretical Electrochemistry Division Business Meeting.

Theoretical Electrochemistry (cont'd)

Thursday, May 16, 1957

General Session (cont'd) **with Paul Delahay presiding**

(FEDERAL ROOM)

1:45 P.M.—"A Tentative Theory of Inhibitions of Aqueous Kolbe Electrolyses" by G. W. Thiessen (Abstract No. 182)

2:05 P.M.—"Electrochemical Polarization, II. Ferrous-Ferric Electrode Kinetics on Stainless Steel" by Milton Stern (Abstract No. 183)

2:25 P.M.—"Relation between Pitting Corrosion and the Ferrous-Ferric Oxidation-Reduction Kinetics on Passive Surfaces" by Milton Stern (Abstract No. 184)

2:45 P.M.—"The Potential of an Electrode of a Voltaic Cell. A New Definition with Justification for the Use of Two Sign Conventions" by J. B. Ramsey (Abstract No. 185)

3:05 P.M.—"The Silver and Thallium Oxide Coulometer" by W. T. Foley (Abstract No. 186)

3:25 P.M.—"Voltammetric Studies at Constant Current in Fused Chlorides" by J. M. Wood, Jr. (Abstract No. 187)

3:45 P.M.—"Rates of Oxidation of Titanium in Fused Salt Baths" by M. E. Straumanis and Ch. Chiou (Abstract No. 188)

4:05 P.M.—"Cathode Potentials during the Electrodeposition of Molybdenum Alloys from Aqueous Solutions" by D. W. Ernst and M. L. Holt (Abstract No. 189)

4:25 P.M.—"Electrodeposition of Iron-Molybdenum Alloys" by Albertine Krohn, L. O. Case, and N. W. Hovey (Abstract No. 190)

ABSTRACTS

Note

In the Index to Authors, the Abstract Number is listed instead of the number of the page on which the Abstract or listing in the Technical Program appears.

ELECTRIC INSULATION

Abstract No. 1

Electric Moments of Certain Partially Fluorinated Esters

J. B. Romans and T. D. Callinan (present address: IBM, Poughkeepsie, N. Y.) U. S. Naval Research Lab., Washington 25, D. C.

Electric moments of six partially fluorinated esters have been determined. Materials studied were liquids at room temperature, known to be chemically inert and thermally stable. All six esters were found to be highly polar compounds exhibiting marked tendencies to associate molecularly; they possessed dipole moments of the order of $2.8\text{–}3.8 \times 10^{-18}$ esu-cm. From experimentally determined permanent electric moments, the most probable molecular configurations were calculated for each of the esters. The predominating structure includes one cis-type configuration. It is evident that the molecules exist, for the most part, in a nonpolar form.

Abstract No. 2

A New Dielectric Liquid for Impregnating Fixed Paper Capacitors

T. D. Callinan (present address: IBM, Poughkeepsie, N. Y.) and J. B. Romans, U. S. Naval Research Lab., Washington 25, D. C.

Fixed capacitors, using kraft paper as the solid dielectric and bis (1H, 1H, 7H-dodecafluoroheptyl) 3-methylglutarate (PFE-774) as the impregnant have been found to possess capacitance to volume ratios higher than similar capacitors impregnated with pentachlorodiphenyl. Furthermore, change in capacitance with temperature is less than 4% within the range −55° to 85°C. Such capacitors have passed military specification MIL-C-25A for accelerated aging by withstanding 85°C and 130% rated voltage for 250 hr. Because the impregnant is unusually flame resistant, thermally stable, of low viscosity, and does not irritate the skin

or cause rubber and plastics to swell and become tacky, this partially fluorinated ester is considered to be worthy of commercial development as a capacitor impregnant. It is believed results of this investigation open possibilities for production of new smaller capacitors particularly adapted to low temperature operation.

Abstract No. 3

Progress Report on the Development of Metal Fiber Paper

H. F. Arledter, Hurlbut Paper Co., South Lee, Mass.

The possibility of manufacturing metal fiber paper in a continuous web on a pilot plant Foudrinier paper machine of 9-in. width has been demonstrated. Paper made of blends of metal fibers with cellulose and inorganic or organic synthetic fibers, as well as 100% metal fiber paper, seems to be feasible. This paper outlines the mechanical properties of metal fiber paper and laminates and their possible uses. Further progress in the manufacture of metal fiber paper will depend on the availability of metal fibers in sufficient amounts and quality to make more extensive trials.

Abstract No. 4

Electric Strength of Perchloryl-fluoride (ClO_3F) Gas

J. J. Chapman and L. J. Frisco, Dielectrics Lab., The Johns Hopkins University, Baltimore 2, Md.

A new gas (ClO_3F) has been examined in uniform and heterogeneous fields. In the former case, 2-cm diameter spheres were used and, in the latter case, point-to-point breakdowns were observed. Observations were extended to mixtures of perchlorylfluoride with SF_6 and N. The contrasting behavior among the pure gases offered by the study of visual corona proved to be of particular interest in nonuniform fields. Perchlorylfluoride may be classified as a high dielectric strength gas since its performance exceeds that of SF_6 under certain circumstances.

Abstract No. 5

International Activities in the Evaluation of Electrical Insulation

L. J. Berberich, Westinghouse Electric Corp., East Pittsburgh, Pa.

The present AIEE and international temperature standards, except for sev-

eral minor revisions, date back to 1912. At that time, insulating materials could conveniently be grouped into two categories, viz., "organic" and "inorganic" or combinations of these. With the advent of many new synthetic materials having thermal stabilities extending over a wide range, it was recognized recently that present standards do not fill the needs of a dynamic electrical industry. Thus, with the U. S. leading the way, a gradual change is taking place in the philosophy of insulation classification by definition to classification by test and performance. The paper reviews, in a broad way, how this is being accomplished on an international basis.

Abstract No. 6

Chemical Rate Phenomena in the Deterioration of Electrical Insulation

T. W. Dakin, Westinghouse Research Lab., East Pittsburgh, Pa.

The basis is presented for a more accurate interpretation of results of physical-type tests to measure the thermal aging of insulation together with a more accurate method of applying results of such tests to predicting insulation deterioration in practice. Since observed physical changes during thermal aging are the result of internal chemical changes in organic material, it is shown that the theory of chemical reaction rates can be applied to analyze experimental data of aging.

Abstract No. 7

Principles for Classification of Insulating Materials

K. N. Mathes, General Electric Co., Schenectady, N. Y.

Classification of insulating materials may be desirable in three important areas: thermal capability, mechanical suitability, and voltage utility. Up to the present, most attention has been paid to the area of the development of functional tests for determining the thermal capability of insulating materials. But mechanical characteristics of insulating materials may be fully as important as thermal properties, and the ability to withstand voltage is implied in the definition of insulation itself. In setting up functional tests, it is important to represent service conditions fairly. In the development of test samples, a "ladder" of tests must be considered.

Selection of adequate test conditions and the choice of proper and significant end points is important, as are the use of statistics and avoidance of its overuse in the interpretation of data. The cost of tests and scope to be covered by material suppliers, fabricator, manufacturer, and user must be considered and balanced carefully. Proper use of functional tests in classifying insulating materials has tremendous implication in the simplification of design and the efficient use of materials.

Abstract No. 8

Thermal Evaluation of Electrical Insulating Materials

J. F. Dexter, Dow Corning Corp., Midland, Mich.

Revisions being made in AIEE Standards will specify that the temperature classification of insulating materials should be based on thermal aging data obtained by functional testing. This radical departure from the traditional method of classification based on chemical composition is necessary because of the rapid development of new synthetic materials. The thermal stability of many of these new materials cannot be established by the simple expedient of classifying them as organic and inorganic.

This new philosophy requires the development of realistic test methods for determining the relative thermal stability of insulating materials. This paper reviews problems associated with the development of test procedures and the progress that is being made.

Abstract No. 9

Thermal Stability of Laminated Thermosetting Plastics

W. B. Kouwenhoven and G. G. Knickerbocker, The Johns Hopkins University, Baltimore, Md.

This paper presents data on mechanical and electrical properties of thermosetting plastics, including paper base, linen base, asbestos and glass base materials at elevated temperatures for periods varying from 1 to 1000 hr. In addition, the paper describes the development of a method of determining the dielectric strength at elevated temperatures in a liquid medium.

Abstract No. 10

Statistical Methods Useful in Predicting Insulation Life

W. E. Horton, Westinghouse Electric Corp., East Pittsburgh, Pa.

Evaluation of insulation materials and/or systems either as samples or in motors under extreme environmental conditions is necessary if experimental data on the insulation life are to be realized in a reasonable length of time. In general, the regression technique is used to estimate the relationship between insulation life and operating condition. The purpose of this paper is to illustrate how this technique and other statistical methods can be used effectively in predicting insulation life.

Abstract No. 11

Application of Extreme Value Statistics on Breakdown Phenomena

J. H. Davidson, General Electric Co., Schenectady, N. Y.

Many engineers have expressed difficulty in analyzing life test data. For many reasons, the conditional failure density concept is to be preferred over all other methods of analyzing life characteristics. Conditional failure density is the probability that an item (or a particular "chain link") will fail at a particular time, provided it has survived up to that time. Conditional failure density has proved most useful in the study of metal fatigue and its value is now being explored in the testing of dielectric materials.

This new concept represents a "breakthrough" in the study of failure phenomena. Very often, insight is given into the failure behavior of a particular product, such as early failures. Conditional failure density might even be used as a property characteristic of a particular material.

Abstract No. 12

Derivation of Electronic Part-Failure Statistics from Material Properties

J. A. Connor and D. I. Troxel, Radio Corp of America, Camden, N. J.

There is a mounting need for suitable "mortality" statistics for component parts to be used in military electronic equipment. Materials investigation

studies are potential "gold mines" of correlation data. The selection, analysis, and interpretation of this data must be based on certain compromise factors dictated by the ultimate statistical utility of the end result. That such efforts can be effective is shown by providing a number of specific examples.

Abstract No. 13

Corona and Its Effect on Insulation —A Résumé

T. W. Liao, General Electric Co., Pittsfield, Mass.

This paper attempts to review the subject of corona and its effect on insulation based on some of the pertinent published articles in this field. The content consists of the following sections: what is corona? how does corona occur? corona inception, effect on insulation with regard to insulation life, insulation surface damage; corona in capacitors, cables, transformers, and other electrical equipment. The references cited in each of the articles give leads to many findings which broaden what is discussed briefly in this paper.

Abstract No. 14

Effects of High-Energy Gamma Radiation on Dielectric Solids

P. H. Klein, General Electric Co., Syracuse, N. Y.

The kinds and magnitudes of radiations present in the various locations near nuclear reactors are discussed as well as the mechanisms of interaction of radiation with matter, viz., group fragmentation, molecular scission, and polymerization. Techniques and locations for obtaining high dose rates are presented. Results of 60-cycle short-time voltage breakdown tests on polyethylene, cellulose acetate, and polyvinyl chloride films along with Formex-varnished wire are given as a function of integrated dosage up to 10^8 roentgens. Extensive electrical tests on a mica-glass-silicone-resin insulation simulating that used in the Submarine Intermediate Reactor's electromagnetic pump are described. Measurements of mechanical property changes of irradiated resins by means of a newly developed penetrometer are presented.

Abstract No. 15

Some Aspects of Missile Package Design

J. P. Morone, P. R. Mallory & Co., Inc., Indianapolis, Ind.

The Signal Corps Engineering Labs., Fort Monmouth, N. J., sponsored a program, recently completed, leading to the establishment of "Principles and Techniques of Integration and Packaging of Printed Circuit Assemblies for Missile Applications" (Contract No. DA-36-039-sc-64451). A number of problems confronting the missile package designer were investigated. Among these were problems related to package integration; mechanical, thermal, and climatic adequacy; miniaturization; and maintenance. The approaches investigated and conclusions reached constitute the basis for this paper.

Abstract No. 16

Production of Prefabricated Circuitry

M. F. Patrick, Westinghouse Electric Corp., Baltimore, Md.

A fundamental approach to the creation of prefabricated circuitry is discussed, covering drafting procedures for implementing a design from schematic to production stage. Also included is a review of some of the various parameters to be recognized by the designer, such as electrical characteristics, mechanical and environmental requirements, and fabrication techniques.

Abstract No. 17

Component Parts for Printed Wiring Assemblies

H. C. Frankel and Wilbur Gross, Signal Corps Engineering Labs., Fort Monmouth, N. J.

The design of component parts used with prefabricated circuits in military and commercial equipment should be guided by those requirements considered necessary to promote satisfactory service with regard to functional suitability, reliability, compatibility with machine handling, etc., during production, transportation, storage and/or operation. Following a summation of these requirements, types available at present of printed and separately fabricated (conventional) components, including

resistive, reactive, electrochemical, thermionic, and other parts, will be exhibited and their capabilities and limitations will be discussed. Current and proposed developments which are expected to overcome these limitations will be described.

Abstract No. 18

Application of Prefabricated Circuitry to Airborne Electronics Equipment

G. B. Way and N. R. Dunbar, North American Aviation, Inc., Downey, Calif.

Mechanization of airborne electronic equipment is illustrated, using standardized, functional circuit elements. These transistorized circuit elements perform the necessary basic information transfer and modification required in an airborne analog flight control system. A design technique and packaging method is discussed wherein equipment using etched circuits, etched cabling, and automatic machine assembly can be produced with a minimum of design and engineering effort. Utilization of proper materials and processes enables the use of double-sided circuits and plated eyelets. The techniques provided a high circuit and component density per unit areas of etched circuit panels.

Abstract No. 19

Use of Shape as a Design Tool

R. K. Jenny, Westinghouse Electric Corp., Baltimore, Md.

Normally used methods for reduction of vibration amplification of phenolic boards at resonance have concomitant disadvantages. Some of these methods and their inherent disadvantages are: (*a*) backing the board with a damping media (sponge rubber, etc.) which introduces humidity and cooling problems; (*b*) stiffening structure or cutting size of boards which increases weight and uncertainty; (*c*) energy absorption device (dynamic absorber, etc.) which increases weight and causes self-excited vibration.

There are usable methods which have no inherent disadvantages. The one described in this paper is use of nonrectangular shapes.

Abstract No. 20

Quality Improvement in the Manufacture of Printed Wiring

E. J. Lorenz, International Business Machines Corp., Poughkeepsie, N. Y.

This paper outlines procedures and processes which have been found to improve the over-all quality of printed wiring cards or boards. Items to be covered include design and artwork, with their influence on the finished product, materials used for the finished product, methods and processes employed during the manufacturing cycle, and tests which are used to determine the quality of the finished product. The design in general is not discussed since the proper choice of materials and processing steps is felt to be the governing factor.

Abstract No. 21

An Approach for Meeting Future Needs of Electronic Components

A. A. Lawson, Melpar Inc., Alexandria, Va.

The purpose of this paper is to stimulate an interest in the future needs of electronic components. Construction and production techniques are considered, as are materials, smaller components, and the setting up of a program of standardization. Various factors which concern the "component user," the "component assemblers," and the "component manufacturer" are discussed. In conclusion, an approach to setting up pertinent factors for advance planning is presented.

ELECTRONICS—LUMINESCENCE

Abstract No. 22

Electroluminescent and Field Effects in Phosphors

H. F. Ivey, Research Lab., Lamp Div., Westinghouse Electric Corp., Bloomfield, N. J.

(No abstract received)

Abstract No. 23

Effect of Electron Traps on the Brightness Waveform of Electroluminescent ZnS:Cu

F. F. Morehead, Jr., Lamp Development Dept., Lamp Div., General Electric Co., Nela Park, Cleveland 12, Ohio

Experiments performed on ZnS:Cu electroluminescent powders embedded in a slightly conducting medium suggest that a field applied in one direction ionizes electrons from emission centers, displacing them to another part of the crystallite. Removal of the field permits only a small fraction of the displaced electrons to recombine (with light emission). Application of a field in the opposite direction accelerates the release of the displaced electrons from traps and their subsequent recombination. If the opposite field rises linearly with time (sawtooth), the resulting light emission rises to a maximum at a particular voltage and then falls as the supply of trapped electrons is exhausted. Variations of the voltage of the maximum with temperature and frequency gives values of trap depth and extension in space in good agreement with general theory if the traps are assumed to be coulombic rather than square wells.

Abstract No. 24

Field Enhancement of X-Ray Excited Luminescence in ZnS.CdS:Mn(Au)

Georges Destriau, Faculté des Sciences, Université de Paris, Paris, France; consultant, Lamp Div., Westinghouse Electric Corp., Bloomfield, N. J.

Electric fields enhance the x-ray excited luminescence of ZnS.CdS:Mn. It has been found that gold additions generally improve the enhancement ratio of such materials (the enhancement ratio is the ratio of the permanent brightness obtained with the field acting to that with the field removed). This action of gold depends on the firing temperature. Composition and firing temperature have been varied in order to obtain the maximum x-ray excited output with field acting.

Abstract No. 25

Characteristics of Electroluminescence at Audio Frequencies

R. M. Rulon and F. Koury, Sylvania Electric Products Inc., Salem, Mass.

Measurements have been made on electroluminescent lamps, in which the phosphor is imbedded in a ceramic dielectric, for voltages up to 1500 and for frequencies between 60 cycles and 10 kc/sec. The effect of various parameters on brightness, current, and wattage is reported.

Abstract No. 26

Electrocathodoluminescence

P. M. Jaffe, Research Dept., Westinghouse Electric Corp., Bloomfield, N. J.

The application of alternating electric fields to certain cathode ray excited ZnCdS:Mn phosphors causes the cathodoluminescence to be enhanced. Total light output (field plus cathode rays) exceeds the sum of the electroluminescence and the cathodoluminescence. Enhancement is a function of the strength and frequency of the applied field, the beam current density, and accelerating potential. There are indications that the cell thickness plays an important role in determining whether quenching is also present.

Abstract No. 27

AC Conductivity Measurements on CdS Crystals under Various Types of Illumination

S. Jaffe, H. Kallmann, B. Kramer, and G. M. Spruch, Physics Dept., New York University, Washington Square New York, N. Y.

Under strong illumination CdS crystals exhibit huge changes in capacitance and dissipation factor under various conditions of exciting radiation. They have been measured with impedance bridges and frequencies up to 100 kc under equilibrium and nonequilibrium conditions (rise and decay of photoconductivity). Two types of electrode arrangements were used in order to eliminate barrier layer effects: (*a*) transparent gold electrodes evaporated directly on the crystals, and (*b*) Mylar sheets (transparent, Al on one side) on each side of the crystal.

With gold electrodes, two classes of crystals are found. One group shows very little change in equivalent parallel capacitance as the conductivity increases, while the other shows a considerable capacitance increase with increasing conductivity. Using Mylar insulated crystals, as the exciting intensity is increased the measured capacitance increases monotonically, while the dissipation factor goes through a maximum. The equivalent parallel capacitance of the crystal itself can be calculated and is found to increase with increasing intensity.

The effect of additional infrared irradiation as well as the effect of the applied voltage is reported.

Abstract No. 28

Action of Temperature on the X-Ray Electroenhancement Effect

J. Mattler, Faculté des Sciences, Université de Paris, Paris, France

The sustained enhancement of luminescence of certain sulfide phosphors irradiated with x-rays and simultaneously submitted to alternating electric fields varies with temperature. For (Zn, Cd)S:Mn the enhancement factor increases regularly as the temperature increases from −155° to +120°C, slowly at low temperatures, strongly at high temperatures. Brightness waves obtained with pulsed x-rays and field enhancement show no modification with temperature. Temperature acts differently on the electroluminescence of the same sulfides; this suggests a different action of the field in the two phenomena.

Abstract No. 29

Thin Film Phosphors

L. R. Koller, Research Lab., General Electric Co., Schenectady, N. Y.

Thin transparent films of phosphors have been prepared by evaporation of commercial powder phosphors *in vacuo*. Luminescent Ag- and Cu-activated films were formed by a two-step process involving heat treatment in gaseous atmospheres subsequent to deposition. Mn-activated films were formed by a single-stage process and did not require any treatment subsequent to deposition. The brightness of these films under cathode ray excitation is about 1/5 of that of the powder from which they are made.

Abstract No. 30

Diffusion of Excitation in CdS Crystals

H. Kallmann, B. Kramer, and A. Orenstein, Physics Dept., New York University, Washington Square, New York, N. Y.

The large photoconductivity observed in CdS crystals is due to the motion of free electrons. If a long crystal with electrodes at one end is illuminated on a small area remote from the electrodes, strong photoconductivity is obtained even if the illuminated area is 1 cm away from the electrodes. Rise time at this distance, dependence of conductivity on distance, and wave length indicate that this conductivity comes about through a diffusion of excitation energy from the illuminated area rather than by reflected, scattered, or fluorescent radiation.

If infrared is added in the previous experiment on a small area, quenching is observed. The amount of quenching is almost independent of the position of the infrared illuminated area whether it is between the visible light and the electrodes or on the side away from the electrodes.

Abstract No. 31

Variations of the Fermi Level in ZnS Phosphors Contaminated with Iron Family Impurities

N. Arpiarian, Laboratoire de Luminescence de la Faculté des Sciences de Paris, Paris, France

Iron family impurities are generally considered as killers. However, in some conditions of concentration and temperature they can have an intensifier effect. This effect is described in ZnS(A, K), where A = Cu or Au, K = Fe, Ni, Co, and explained by introducing a variable Fermi Level in the forbidden band. The Fermi Level shows itself particularly in the ZnS(Au, Co) phosphors. It rises with decreasing temperature in any case, and with increasing Co concentration.

Abstract No. 32

Investigations in $CuGaS_2$-ZnS and $AgGaS_2$-ZnS Systems

E. F. Apple, Research Lab., General Electric Co., Schenectady, N. Y.

$CuGaS_2$ and $AgGaS_2$ have structures closely related to zinc-blende. $CuGaS_2$

and ZnS form a series of solid solutions over the entire range. Emission under 3650 Å excitation shifts from green to red with increase in $CuGaS_2$ concentration. Samples with more than 20 mole % $CuGaS_2$ do not emit at room temperature, whereas at −195°C, fairly bright luminescence is observed. $AgGaS_2$ is soluble in ZnS to about 5–10 mole %, above which separation of Ag_2S is observed. Emission under 3650 Å excitation shifts from the blue (0.01% $AgGaS_2$) to yellow (10% $AgGaS_2$).

Abstract No. 33

Energy Storage and Decay in Various Phosphors

H. Kallmann and E. Sucov, Physics Dept., New York University, Washington Square, New York, N. Y.

The rise curve method of Kallmann and Spruch has been applied to the determination of lifetime distribution of trapped electrons in various phosphors. Comparison of rise curve deficiency areas with areas under curves of decay of phosphorescence indicates that, for most phosphors, the recombination process is completely radiative. Comparison with areas under stimulation curves indicates that even when the phosphorescence decay process is completely radiative IR causes nonradiative transitions. A stimulable phosphor is distinguished from other phosphors not by the difference in the number of traps but by the fact that IR induces predominantly radiative recombinations of trapped electrons, while in other phosphors IR induces nonradiative transitions. Since substances with practically no phosphorescence or stimulation store large numbers of electrons for long periods of time, this lack of phosphorescence and stimulation is not due to lack of traps but to the overwhelming effect of nonradiative transitions.

Abstract No. 34

Luminescence of 'Self-Coactivated' ZnS:Cu

M. H. Aven and R. M. Potter, General Electric Co., Nela Park, Cleveland, Ohio

ZnS:Cu has been prepared which shows only a simple orange emission band. The results of others who found blue or yellow emission bands are ascribed to impurities. The effect of

oxygenous impurities on ZnS:Cu was investigated. When ZnS:Cu was quenched to room temperature from 600°C or higher, an unstable green fluorescence was found in place of the normal orange. Also, ZnS:Cu fired under strongly reducing conditions was found to develop a stable green emission. Models for the orange and green centers are proposed which explain experimental results.

Abstract No. 35

Process of Light Stimulation in ZnS Phosphors

H. Kallmann, W. Schneider, and M. Sidran, Physics Dept., New York University, Washington Square, New York, N. Y.

Sucov has shown that stimulability is caused by the predominance of radiative over nonradiative recombinations produced by infrared. Decay of stimulated light, while IR is applied, is very similar to that of phosphorescent decay and follows a $C/(a + t)^n$ law with n close to one during the first part of the decay; later n approaches two. Such a smooth decay is observed only with newly excited samples; if the material is partially exhausted either by natural decay or by preceding IR irradiation, the decay of stimulation shows first an increase, goes through a maximum, and only thereafter decays as above. The more the sample is exhausted the later the maximum occurs; the stronger the IR, the earlier it appears. Newly excited samples, even if their excitation is weak, show no maximum. A theory is presented which explains these features. It is based on the existence of two activators, one with very high radiation recombination probability, the other with a much smaller one. Thermal interactions and those produced by IR between these activators explain the above described effects.

Abstract No. 36

Energy Transfer and Sensitization in Single-Crystal Phosphors

R. Leach, Dept. of Physics, The University, Hull, U. K.

An experimental study is made of the luminescence characteristics of single crystals of fluorite activated by Ce^{3+} and Mn^{2+} ions, with particular reference to energy transfer between the two acti-

vators. Previous results of Ginther for such phosphors in powder form are confirmed, but new evidence on transfer processes is provided by quantitative measurements of absorption bands, yielding oscillator strengths, and of fluorescence life times. In addition, experiments are made on diffusion of activators into fluorite at relatively low temperatures, approximately 600°C. Results indicate association of activators rather than random dispersal as previously assumed.

Abstract No. 37

Some Aspects of Quenching of Fluorescence in Organic Liquids

M. Furst and H. Kallmann, Physics Dept., New York University, Washington Square, New York, N. Y.

The additivity of different solutes in producing self-quenching, and the ability of a solvent to transfer energy to a solute in fluorescent solutions are investigated. Solutes with different chemical structures but similar fluorescence efficiency and wave lengths of absorption and emission are found to behave independently in the solution so that no combined self-quenching occurs under high energy excitation. Mixtures of solutes with related chemical structures are also investigated. Experiments on characteristics of solvents which transfer energy efficiently or poorly are described. They show that higher levels of excitation are more easily quenched in solvents which transfer poorly.

Abstract No. 38

Infrared Photography with the Help of Various Inorganic Phosphors

H. Kallmann and J. Rennert, Physics Dept., Institute of Mathematical Sciences, New York University, Washington Square, New York, N.Y.

Inorganic phosphors are capable of storing excitation energy or electrons. These stored electrons can be released or made to recombine by IR irradiation. If a previously excited phosphor is illuminated with u.v., its fluorescence at the beginning is larger than that of the not pre-excited phosphor. To make IR pictures, the phosphor is pre-excited, then illuminated with the IR radiation to be depicted. The areas struck by IR radiation have less trapped electrons

than the other areas. These areas can be made visible or permanently recorded by irradiating the sample after IR exposure with u.v. or with IR radiation (if it produces radiative recombinations). In this way it was possible to make IR pictures with IR radiation of 2.5 μ. Pre-irradiation can precede, and the radiation which makes the picture visible can follow the IR exposure by weeks.

Abstract No. 39

Time Constants of Alpha- and Electron-Produced Light Flashes

G. Brucker, Signal Corps, Camp Evans, N. J., and H. Kallmann, Physics Dept., New York University, Washington Square, New York, N. Y.

So-called time constants of various organic and inorganic materials are presented. They range from 3 to 100 $\times$ 10^{-9} sec. There is some correlation between strength of absorption for the organic materials and time-constants. The latter are the same for α and electron excitation. No indication of long time emission was observed; if such emission exists, it must be of small amplitude. The ratio of efficiencies for α and electron excitation is approximately the same for all investigated material in spite of the fact that they differ in time-constants and efficiencies tremendously. These findings indicate that quenching due to high density of excitation is a very fast process, faster than the shortest light emission process. A theory which explains these effects is presented; it is based on the migration of the excitation energy out of the excitation channel.

Abstract No. 40

Resolution of Thermoluminescence Curves

C. H. Haake, Research Dept., Westinghouse Electric Corp., Bloomfield, N. J.

The resolution of thermoluminescence curves is discussed analytically. With a given difference of trap depths, the only variable which may be used to change the resolution is the heating rate. The mathematical expression for the resolution with increasing heating rate shows two competing processes: (*a*) increasing separation of two neighboring glow peaks, and (*b*) increasing halfwidth of the peaks. The latter predominates in

all cases and resolution can be enhanced only by decreasing heating rates.

Abstract No. 41

Potential Energy Curves for Phosphors

K. H. Butler, Sylvania Electric Products Inc., Salem, Mass.

A method of calculating potential energy curves of activator ions in phosphors from the emission and excitation spectra is described. Calculated curves for some alkali halide phosphors and for some orthophosphate phosphors are discussed.

Abstract No. 42

A Review of the Measurement of the Quantum Efficiency of Inorganic Phosphors

J. Tregellas-Williams, Research Lab., General Electric Co., Ltd., Wembley, England

Various methods of measuring the quantum efficiency of phosphors have been used in the past; these include absolute light measurement, a substitutional method, derivation from lamp efficiencies, and a calorimetric method. These are described and the results discussed and compared with those derived from original work on the lamp efficiency method and a modified microcalorimeter. A summary of published and unpublished values of quantum efficiency is appended.

Abstract No. 43

Temperature Characteristics of Phosphors for Use in High Pressure Mercury Vapor Lamps

A. H. McKeag, Research Labs., General Electric Co., Ltd., Wembley, England

This paper gives details of the preparation of improved barium strontium lithium silicate phosphors for use in high pressure mercury vapor (H.P.M.V.) lamps and shows that temperature characteristics of these phosphors are particularly sensitive to conditions of preparation. Color corrected H.P.M.V. lamps made with these improved phosphors show an appreciable improvement in color rendering properties. Other phosphors for use in H.P.M.V. lamps are also considered.

Abstract No. 44

Temperature Dependence of Fluorescence

R. W. Mooney, Sylvania Electric Products Inc., Towanda Pa.

Equipment for measuring the temperature dependence of fluorescence with excitation either by 2537 or 3600 Å radiation is described. Results on various phosphors including zinc-modified orthophosphates are discussed.

Abstract No. 45

Gray Discoloration in Calcium Halophosphates

W. L. Wanmaker and M. G. A. Tak, Philips Research Labs., N. V. Philips Gloeilampenfabrieken, Eindhoven, Netherlands

Calcium halophosphates can assume a light gray color when refired at 500°–600°C both in air and in a reducing atmosphere. The gray color due to oxidation is more pronounced in the presence of alkali, and occurs in practice during the baking process (removing of organic binder) of fluorescent lamps. The gray color due to reduction is observed during the evacuation of the fluorescent lamp coated with calcium halophosphate. The influence of the presence of Na and Al on the discolorations found is discussed and a theory of the observed phenomena is given.

Abstract No. 46

Cerium-Activated Halophosphate Phosphors

S. T. Henderson and P. W. Ranby, Thorn Electrical Industries Ltd., 52-56 Lawrence Rd., Tottenham, N. 15, England, and Great Cambridge Rd., Enfield, Middlesex, England, respectively

This paper describes the characteristics of a new group of alkaline earth halophosphate phosphors activated by Ce and Mn, and contrasts their behavior with that of halophosphates containing other primary activators. In their preparation, these Ce-activated materials show marked differences from other previously known halophosphates, but the luminescent properties are similar to those of the tin-activated system. The behavior and possible uses of these phosphors in fluorescent lamps are described.

Abstract No. 47

Luminescence of Tin-Activated Strontiumorthophosphate

H. Koelmans and A. P. M. Cox, Philips Research Labs., N. V. Philips' Gloeilampenfabrieken, Eindhoven, The Netherlands

The introduction of Al, Zn, Mg, Ca, or Cd in $Sr_3(PO_4)_2$ produces a new crystal phase which is probably isomorphous with $\beta Ca_3(PO_4)_2$. Activated with tin this Sr-orthophosphate gives a strong luminescence with a maximum at about 6300 Å under excitation with λ2537 Å.

Abstract No. 48

Zinc Modified Orthophosphate Phosphors

M. J. B. Thomas and K. H. Butler, Sylvania Electric Products Inc., Salem, Mass.

The preparation, properties, and uses of tin-activated calcium and strontium orthophosphate phosphors, modified by replacement of a portion of the alkaline earth metal by zinc, are described. The effect of varying composition on emission and excitation spectra is discussed.

Abstract No. 49

Transition Probability Ratios in KCl:Tl and KCl:In

F. E. Williams, P. D. Johnson, and B. Segall, Research Lab., General Electric Co., Schenectady, N. Y.

Transition probability ratios for the principal impurity absorption bands of KCl:Tl and KCl:In were calculated including the effect of crystal interactions. The excited states are assumed to have the character of $^1P_1^0$ and $^3P_1^0$ states of the sp configuration. In the formulation, the spin-orbit interaction is applied after the crystal interactions. Experimental transition energies for the crystal, rather than for the free ion, are used in the calculation. Satisfactory agreement with experiment is found.

Abstract No. 50

Shape of the F-Band in KCl

J. J. Markham and J. D. Konitzer, Zenith Radio Corp., Chicago, Ill.

In recent years detailed theories of the shape of optical absorption bands in solids have been developed. One has been unable to check these with experi-

ments due to the lack of detailed data. The shape of the F-center in KCl at 300°K, 195°K, 78°K, and 5°K has been measured and a comparison has been made. Results are presented.

Abstract No. 51

Interaction of Color Centers in the Alkali Halides

W. D. Compton and John Lambe, U. S. Naval Research Lab., Washington, D. C.

A study of the interaction among various color centers of the alkali halides has been made. The following experimental observations have led the authors to postulate such an interaction: (*a*) If F-centers and M- or R_1-centers were present in the crystal, excitation in the F-band gave emission that was characteristic of the M- or R_1-centers but not of the F-center. (*b*) Excitation with polarized F-light gave polarized M- or R_1-emission. (*c*) Irradiation with polarized F-light produced dichroism in the F, M, R_1, and R_2-bands. (*d*) Excitation in the R_2-band of NaCl gave emission characteristic of the R_1-center.

Abstract No. 52

Luminescence of Color Centers

John Lambe and W. D. Compton, U. S. Naval Research Lab., Washington, D. C.

A study has been made of the luminescent properties of F-, M-, and R-centers in alkali halide crystals. Special emphasis was placed on the symmetry properties of these centers. In order to investigate this, the luminescent center is excited with polarized light and the resulting emission is analyzed for polarization. These measurements can then be used to determine some of the symmetry properties of the luminescent center. Results thus obtained were in good agreement with current theory for the F-center and M-center. In the case of R-centers results were more complex and a simple analysis was not applicable.

Abstract No. 53

Experiments on Color Center Production in KI:Tl

H. N. Hersh, Zenith Radio Corp., Chicago, Ill.

KI:Tl has been subjected to x-irradiation on electrolysis and rendered non-

stoichiometric with excess K; absorption spectra have been measured. Measurements show that the addition of TlI to KI decreases the stability of the F-centers and results in more or less permanent coloration of the crystals. X-irradiation destroys the u.v. luminescence properties of the phosphor.

Abstract No. 54

Color Centers in Cadmium Fluoride

M. Rubenstein and E. Banks, Dept. of Chemistry, Polytechnic Institute of Brooklyn, Brooklyn 1, N. Y.

Single crystals of CdF_2, purified, and containing additions of NaF, CaF_2, and equimolar mixtures of NaF and CeF_3, were grown from the melt in carbon crucibles in a helium atmosphere. Transmission spectra were obtained before and after x-irradiation on slices about 1.5 mm thick, at 28°C, −78°C, and −190°C. Crystals containing 0.05–5 mole % NaF showed a radiation-induced absorption near the fundamental absorption edge, which is stable at room temperature, and an absorption stable at −190°C, which disappears between −190°C and −78°C. CdF_2, pure, or containing CeF_3 or NaF + CeF_3 in solid solution, all show only one absorption band, unstable above −10°C.

ELECTRONICS—SEMICONDUCTORS

Abstract No. 55

Compound Semiconductors

D. A. Jenny, RCA Labs., Princeton, N. J.

A review of the development and the present status of compound semiconductor research is presented followed by an outline of the practical implications. The study of compound semiconductors has contributed much to the basic understanding of semiconductors although many phenomena are still awaiting interpretation. New application areas are being opened up by the unusual properties of some recently discovered compounds, and at least one of the new compound materials is a potential competitor of Ge andSi.

Abstract No. 56

New Semiconductors

J. H. Wernick and K. E. Benson, Bell Telephone Labs., Murray Hill, N. J.

(No abstract received)

Abstract No. 57

Carrier Transport Phenomena in Germanium Bicrystals

H. F. Mataré and B. Reed, Research Lab., Tung-Sol Electric, Inc., 200 Bloomfield Ave., Bloomfield, N. J.

Medium angle grain boundaries (tilt angle between 5° and 25°) were grown from bicrystal seeds to study electrical properties of such interfaces. It is assumed that impurity diffusion or segregation at the interface is less important for these angles of misfit than the dangling bonds. Differential resistivity and lifetime of minority carriers show a strong influence of the sheet arrangement of dangling bonds with their energy level near the middle of the band gap.

Abstract No. 58

Photosensitivity of Ge Grain Boundaries

O. Weinreich and H. F. Mataré, Research Labs., Tung-Sol Electric, Inc., 200 Bloomfield Ave., Bloomfield, N. J.

Grain boundaries in Ge form a *P*-type region. One means of investigating potential jumps set up in grain boundaries consists of measuring the photovoltaic effect. If a light beam approaches the grain boundary, an increasing photovoltage is measured which then decreases and drops to zero when the position of the beam is approximately symmetric across the boundary. After crossing the boundary, the polarity of the emf is reversed. Results of the spectral response and temperature dependence are reported and will be discussed.

Abstract No. 59

Growth and Definition of Bicrystals

R. Wegener and H. F. Mataré, Research Lab., Tung-Sol Electric, Inc., 200 Bloomfield Ave., Bloomfield, N. J.

The investigation of electrical properties of grown boundaries gave impetus

to the growth of the bicrystals to be discussed. The possible definition of bicrystals in terms of the lattice directions of one member and with respect to the grain boundary is discussed. For symmetrical configurations, the limiting range of unique combinations is given. Methods for seed orientation and preparation are described. Variations necessary in procedure to achieve desired precision limits of bicrystals are discussed.

Abstract No. 59A

Dissociation Pressure and Cohesive Energy of Indium-Phosphide

K. Weiser, RCA Labs., Princeton, N. J.

(No abstract received)

Abstract No. 60

Impurity Diffusion in Germanium and Silicon

M. Tanenbaum, Bell Telephone Labs., Inc., Murray Hill, N. J.

Studies of the diffusion coefficients of Group III and Group V impurities have shown that, for a wide range of concentrations of semiconductor interest, diffusion coefficients of impurities are independent of concentration and have well-defined activation energies. Recent studies of these diffusion coefficients as a function of temperature are discussed and values obtained by various investigators are presented. Diffusion mechanisms are also discussed. Solutions of the diffusion equation for some of the boundary conditions of interest are to be presented. Selected device applications are discussed to demonstrate how the impurity distribution peculiar to diffusion processes affects device parameters.

Abstract No. 61

Effects of Heat Treatment on Silicon Diffusion-Created Devices

C. Levi and I. Weiman, Pacific Semiconductors Inc., 10451 W. Jefferson Blvd., Culver City, Calif.

This paper discusses the dependency of diffusion device characteristics on bulk lifetime with particular emphasis on lifetime changes occurring during the diffusion process heat treatment. Results of experimental work are correlated with theory. Diode parameters such as recovery time and forward currents are found to follow predicted relationships. Reverse saturation currents appear to be

dependent on changes other than lifetime.

Abstract No. 62

Oxygen as Impurity in Transistor Grade Silicon

W. Kaiser and P. H. Keck (Present address: Sylvania Electric Products Inc., Bayside, N. Y.), Signal Corps Engineering Labs., Fort Monmouth, N. J.

The oxygen content of pulled Si crystals is correlated with the infrared absorption band at 9 μ. Diffusion of oxygen out of and into a liquid zone of Si was studied under a variety of experimental conditions. In vacuum, in a hydrogen or in an inert gas atmosphere, oxygen leaves the melt rapidly while an increased 9 μ absorption is found after the melt was kept in contact with an oxygen atmosphere or a SiO_2 surface for a short time.

Abstract No. 63

Ternary Distribution Coefficients in Silicon*

David Navon, Transitron Electronic Corp., 168–182 Albion St., Wakefield, Mass.

The doping effect of impurities introduced into Si by a carrier metal is of interest in producing alloy contacts. One can redefine the distribution coefficient to apply to these ternary systems. Values for this coefficient are presented for donor and acceptor impurities introduced into Si at different temperatures by a carrier metal. They are, in general, smaller than the normal coefficients for impurities such as Sb, As, and Ga.

* This work was supported by the U. S. Signal Corps under contract No. DA-36-039-sc-72714.

Abstract No. 64

Evaporation and Alloying of Metals to Silicon

J. M. Goldey, M. Tanenbaum, and N. Holonyak, Jr. (now on military leave with the U. S. Army Signal Corps), Bell Telephone Labs., Inc., Murray Hill, N. J.

A general discussion on the several aspects of evaporating and alloying of contacts to Si is presented. The Al-Si system is described in some detail. Prepa-

ration of materials and the degree of vacuum found satisfactory are mentioned. A brief discussion of outgassing of the Si substrate, masking and heating of the substrate, and evaporation on substrates at different temperatures is given. Procedure of alloying evaporated materials for Si is described.

Abstract No. 65

Transistor-Grade Silicon, I. Preparation of Ultrapure Silicon Tetraiodide

Bernard Rubin, G. H. Moates, and J. R. Weiner, Radiochemistry Section, Components and Techniques Lab., Air Force Cambridge Research Center, Air Research & Development Command, Bedford, Mass.

A stepwise method of preparing and purifying SiI_4 has been found, involving the direct combination of the elements, recrystallization of the product, followed by sublimation and zone purification steps. Values of the segregation coefficients of several impurity elements have been determined to concentrations of less than one part of impurity per billion parts of SiI_4 in 60 passes, using a 50 cm length charge.

Abstract No. 66

Transitor-Grade Silicon, II. Zone Purification of Silicon Tetraiodide

G. H. Moates and Bernard Rubin, Radiochemistry Section, Components & Techniques Lab., Air Force Cambridge Research Center, Air Research & Development Command, Bedford, Mass.

Effective segregation coefficients of various impurities determined from a study of zone melting of SiI_4 are given. The apparatus and technique employed are discussed, and limiting equilibrium conditions are defined. The significance of the results is illustrated by calculation of ultimate distribution profiles. Effects on the effective coefficient of velocity of crystallization, diffusion coefficient, and convection are discussed. Yield of purified SiI_4 is related to K_{eff}, charge length, zone length, and initial concentration.

Abstract No. 67

Paper withdrawn

Abstract No. 68

Contribution to the Floating Zone Technique for Refining Silicon

E. Buehler, Bell Telephone Labs., Inc., Murray Hill, N. J.

A recycling automatic floating zone apparatus for Si has been assembled. Features of this equipment such as the mechanical drive, the control panel, and a self-stabilizing r.f. heating circuit are described. Single-crystal Si of 16,000 ohm-cm and 1500 μsec lifetime has been produced in the apparatus. Results on the evaluation of raw material, lifetime degradation produced by heating, and the effects of the process variables during refining are described.

Abstract No. 69

Heat Treatment of Silicon Using Zone Heating Techniques

H. C. Theuerer, J. M. Whelan, H. E. Bridgers, and E. Buehler, Bell Telephone Labs., Inc., Murray Hill, N. J.

New insight into the mechanism for changes in Si with solid-state heat treatment has been obtained with the aid of the floating zone apparatus normally used to refine Si. Through the use of this technique, it has been established that contaminants left on the Si surface even after careful etching and washing procedures are a controlling factor in the observed heat treating effects.

Abstract No. 70

Optical Measurement of Film Growth on Silicon and Germanium Surfaces in Room Air

R. J. Archer, Bell Telephone Labs., Inc., Murray Hill, N. J.

The rate of growth of films, presumably oxide films, on polished Si and Ge surfaces in room air following a HF rinse was determined by measuring the ellipticity of reflected polarized light. Film thickness vs. log time plots are linear after about 10^4 sec with slopes of 6.8Å/decade (Si) and 8.1Å/decade (Ge). Immediately after the HF rinse the films are 10–15Å thick. After one day in air they are 25–30Å thick.

Abstract No. 71

Bonding Material for Making Contacts to Etched *P*-Type Silicon

D. R. Mason and J. C. Sarace (Present address: Dept. of Chemical and Metallurgical Engineering, University of Michigan, Ann Arbor, Mich.), Bell Telephone Labs., Inc., Murray Hill, N. J.

Mo clad on one side with Al has been used to form structurally sound ohmic contacts to etched *p*-type Si wafers containing *p-n* junctions. The desired Al-Si solid solution can be formed before a substantial amount of Al reacts irreversibly with the Mo. Coefficients of expansion are sufficiently well compensated so that the wafer does not crack during fabrication. Damaged wafers almost invariably result when structural sections of Al are used.

Abstract No. 72

Description of Electrochemical Jet Etching of Silicon

Albert Mark, Signal Corps Engineering Lab., Fort Monmouth, N. J.

Electrolytic jet etching of Si is described and factors effecting etching action are discussed. Geometry of cavity is approached from a fluid dynamic point of view. Cavities made with laminar flow and tubulent flow are shown to differ in terms of the velocity distribution of stream at moment of impact with a Si wafer. Extremely flat bottom cavities are made by employing the least distorted cross section of a flattened parabolic liquid stream. A new versatile laboratory jet apparatus is shown.

Abstract No. 73

Mechanism of Electrolytic Rectification

P. F. Schmidt, Research Div., Philco Corp., Philadelphia 34, Pa.

At voltages below forming voltage, the current in the anodic direction is blocked by the space charge of electrons getting trapped in the oxide. At very high fields, avalanche breakdown occurs in localized spots. Essentially the same picture is true in the cathodic direction except that here protons penetrate into the oxide, neutralizing the negative space charge, and thus permitting continuous current flow. Experiments in

electrolytes not containing protons support this view.

ELECTRONICS—THERMIONIC CATHODES

Abstract No. 74

Recent Work on Surface Properties of Oxide Semiconductors

J. J. Lander, Bell Telephone Labs., Inc., Murray Hill, N. J.

(No abstract received)

Abstract No. 75

Thermionic Emission Characteristics of Thoriated Rhenium*

W. E. Nexsen, Jr., and G. B. Gaines, Battelle Memorial Institute, Columbus, Ohio

Preliminary investigations show that thoriated rhenium behaves very similarly to thoriated tungsten as far as thermionic emission is concerned. Emission from the two, when put through a similar processing and activation schedule, is of the same order of magnitude, that is, many orders of magnitude larger than from the pure metal. Thoriated rhenium activates at a lower temperature than thoriated tungsten, indicating a larger diffusion coefficient for thorium through rhenium than for thorium through tungsten.

* Sponsored in part by The Air Force Cambridge Research Center.

Abstract No. 76

Thermionics and Evaporation Properties of Some Lanthanide Oxides

D. L. Schaefer, Power Tube Dept., General Electric Co., Schenectady, N. Y.

The following properties of lanthanum oxide, neodymium oxide, samarium oxide, and gadolinium oxide have been measured: (*a*) the thermionic work function and Richardson's constant for the oxides on tantalum base metal; (*b*) evaporation rates of the oxides and the activation energies for evaporation; (*c*) the minimum thermionic work function of the evaporant on a tungsten collector as well as the stable value

which is reached when many times the minimum value has been collected.

Measured properties for each of the oxides are very similar, lanthanum oxide showing the greatest difference. Thermionic work functions are in the range of 2.9–3.2 e.v.; Richardson constants fall between 30 and 55, and activation energies for evaporation are between 6.8 and 7.4 e.v.

Abstract No. 77

Emission from Barium on Tantalum Carbide

J. E. White, Electronics Lab., General Electric Co., Syracuse, N. Y.

Refractory carbides have been used to a limited degree as emission-suppressing coatings on grids in power tubes. Suppression of emission occurs because the monolayer of emissive material, such as Th or Ba, which ordinarily produces grid emission, dissolves into the carbide. The work to be described constitutes a systematic investigation of absorption and evaporation of Ba from one of the interesting carbides, and demonstrates that considerable thermionic densities can be obtained from TaC saturated with Ba.

Abstract No. 78

Preparation and Properties of the Magnesium Oxide Cold Cathode

Dietrich Dobischek, Evans Signal Lab., Fort Monmouth, N. J.

(No abstract received)

Abstract No. 79

Reactions of Oxide Cathodes with Gases at Low Pressures

R. J. Ruka and E. A. Gulbransen, Research Labs., Westinghouse Electric Corp., Pittsburgh, Pa.

Recent experimental work by Wagener and others has shown quantitatively that a relation exists between low pressures of certain gases and the electron emission in oxide cathode systems. A thermochemical analysis is made for the reactions of H_2O, O_2, CO, OH, SO_2, CO_2, and H_2 and compared with their reported action on the "poisoning" of

"activation" of oxide coated cathodes. The possible role of negative ions is discussed.

Abstract No. 80

The Electron Microscopy of Alkaline Earth Carbonates*

C. F. Tufts, Research Labs., Sylvania Electric Products Inc., Bayside, N. Y.

An adaptation of the carbon replica technique has been developed which: (*a*) retains true specimen geometry by eliminating destructive dispersion manipulations during specimen preparation; (*b*) reveals size, shape, and surface geography to less than 100Å, permitting precise determination of both aggregate and single particle geometry; (*c*) furnishes a qualitative indication of the degree of crystal perfection for single particles; (*d*) serves as a monitor of interpretation for B.E.T. and Fisher Sub-Sieve size data.

* Supported in part by U. S. Navy Contract NO bs 8023.

Abstract No. 81

Relationship between Thermal Decomposition in Vacuum and Macrostructure of Alkaline Earth Carbonates*

B. Wolk and J. G. Buck, Research Labs., Sylvania Electric Products Inc., Kew Gardens, N. Y.

The control of quality in electronic tubes processed by production equipment depends on numerous factors. Among these factors are those involving time and temperature conditions for effective conversion of the cathode coating from the carbonate to the emitting oxide. A technique is described for evaluating relative thermal decomposition properties of different cathode carbonates under simulated tube processing conditions. Various observations on the relationship between the macrostructure of cathode carbonates and the thermal decomposition behavior are described.

* This work was supported by U. S. Navy Contracts NOBs 5369 and NOBs 8023.

Abstract No. 82

Study of the Interface Impedance Characteristics of Seven Commercial Cathode Nickel Alloys

C. D. Richard, Jr., and A. M. Bounds, Superior Tube Co., Norristown, Pa.

Measurements of interface impedance were made on 6BC8 tubes at several points during a 2000-hr accelerated life test. A comparison is made between heats of varying Si content from seven different commercial cathode Ni alloys. An attempt is made to show the variation between heats and to rate the alloys with respect to interface impedance buildup. A preliminary conclusion is that the tube structure and processing history are at least as important in the development of interface impedance as the composition of the cathode Ni alloy and its coating.

Abstract No. 83

Considerations of Oxide Cathode Interface Impedance

A. P. Haase, R. E. Holmes, and F. J. Schmidt, General Electric Co., Owensboro, Ky.

Interface-impedance effects have been observed under a number of operating conditions in a modern computer tube. A comparison of interface-impedance formation rates under these conditions is made and problems associated with the measurement of short time-constant interface impedances are discussed.

Also reported are typical interface-impedance formation characteristics of commonly used cathode alloys as measured in a triode-testing vehicle under varied operating conditions.

Abstract No. 84

A Study of the Molded Nickel Cathode

C. P. Hadley, W. G. Rudy, and A. J. Stoeckert, Tube Div., Radio Corp. of America, Lancaster, Pa.

Research work on the molded nickel cathode is described. Results are given regarding the effects on emission and life of variations in nickel powder, alkaline-earth-carbonates, reducing agents, sintering, and activation. Data on pulsed emission are presented and

results are compared with those of previous workers.

Abstract No. 85

New Developments in the L-Cathode

C. A. M. van den Broek and A. Venema, Philips Research Labs., Eindhoven, Netherlands

A disadvantage of the original L-cathode with a (Ba, Sr)CO_3 filling is the generation of CO_2 during processing, which causes oxidation of the porous W. Also, in some cases a need exists for a lower evaporation rate of the alkaline earth metals and oxides.

With a filling of a pressed mixture of alkaline earth aluminates and a reducing agent (e.g., W) considerable improvement both in the gas production during processing and in the amount of evaporated material has been obtained.

ELECTRONICS—INSTRUMENTATION

Abstract No. 86

Equipment for the Autographic Determination of the Electrical Resistance of Metals at High Temperatures

G. A. Moore, National Bureau of Standards, Washington, D. C.

Recent extensions of metallurgical interests necessitate precise knowledge of numerous solid-state reactions not always conveniently observed by traditional methods. The change of electrical resistivity with temperature is both an important fundamental property and a valuable tool for observing certain reactions within metals.

The high sensitivity apparatus described autographically records the changing electrical resistances of a wide variety of metallic specimens while in vacuum or protective atmosphere and automatically carried through appropriate temperature cycles.

Abstract No. 87

Methods of Measuring High Resistances*

E. F. Turner, Jr., George Washington University, Washington, D. C.

A discussion is presented on basic methods of measuring resistance, point-

ing up the special problems encountered in the range of 10^{12}–10^{16} ohms. A continuous measuring instrumentation is described, and compared with the Wheatstone Bridge. Data on the resistivities of several commercial plastics obtained by the two methods are given.

* Work done at the Naval Research Laboratory, Washington, D. C.

Abstract No. 88

Calibration of Kinescope Test Sets for Color Balance and Light Output

G. P. Kirkpatrick and A. E. Hardy, Tube Div., Radio Corp. of America, Lancaster, Pa.

The routine calibration of color kinescope test sets for color balance and light output is achieved by means of spectroradiometrically calibrated kinescopes. The operation of these kinescopes is checked by means of a three-filter colorimeter. Details of the calibration techniques are discussed.

Abstract No. 89

Interferometric Calibration of Kinescope Aluminum Film Thickness Meters

G. P. Kirkpatrick and T. A. Saulnier, Tube Div., Radio Corp. of America, Lancaster, Pa.

The application of multiple-beam interferometry to the calibration of aluminum-film-thickness meters used to monitor aluminized kinescope screens is discussed. Comparison of interferometrically observed and calculated values of aluminum thicknesses indicates that the calculations are reliable in the range of 1300 to 5000 A.U., provided care is exercised in the preparation of the calibration plates. The interferometric check is far superior to that obtainable by quantitative chemical analysis. Empirical data and suggestions for further applications are included.

Abstract No. 90

An Apparatus for Vacuum and Atmospheric Differential Thermal Analysis

J. G. Rabatin and C. S. Card, Lamp Wire and Phosphors Dept., General Electric Co., Cleveland, Ohio

Apparatus described is suitable for differential thermal analysis of sub-

stances from full vacuum to 400 psi in gases such as O_2, N_2, H_2, CO_2, SO_2, H_2S, and NH_3. The atmospheric chamber housing the furnace is large enough to fire samples up to 100 g. The furnace will operate up to 1350°C.

Performance characteristics and sensitivity of DTA apparatus are reported. Applications to analysis of various substances under various pressures and gases are described.

Abstract No. 91

Application of Lead Sulfide Detector to the Study of Luminescence in the Near Infrared Region

J. M. Goldstein, W. M. McNabb, and J. F. Hazel, Dept. of Chemistry, University of Pennsylvania, Philadelphia, Pa.

Conventional fluorometers and spectrofluorometers utilize photomultiplier tubes for maximum sensitivity. In the present work an attempt was made to study luminescence to the near IR region, where photomultipliers have no response, by the utilization of lead sulfide detectors.

In the present instrument the luminescent radiation is chopped at 60 cps, amplified by a conventional amplifier, and the signal is phased by a special phasing device so that it can be fed to a conventional d-c recorder without the customary signal rectification.

Abstract No. 92

Effect of Current Drains on Cadmium Standard Cells

G. D. Vincent, Standard Cell Dept., The Eppley Lab., Inc., Newport, R. I.

Various sizes of commercial unsaturated cadmium standard cells were subjected to current drains of from 0.5 to 12 μa (0.2–23 $\mu a/cm^2$). The terminal voltages of these cells were observed for several years. The relationship between change in voltage and time is not a linear one; an approximation of the decrease is 11 μv/coulomb of current passed per reciprocal centimeter squared of electrode area.

ELECTRONICS—SCREEN APPLICATION

Abstract No. 93

Wet and Dry Strengths of Cathode Ray Screens

R. W. Spencer, N. W. McCready, and Wm. Stericker, Philadelphia Quartz Co., Public Ledger Bldg., Philadelphia 6, Pa.

In the manufacture of cathode ray tubes the dry strength of the screen has become more important because of lacquer filming before aluminizing. A method has been developed for testing dry strength which is based on the same general principles as thosed used in determining wet strength. Strictly speaking, the new method tests rewet strength. It is more reproducible than air-stream methods.

Wet and dry strengths vary independently of each other with different concentrations of potassium silicate and reactants.

Abstract No. 94

Sedimentation Volumes of a Phosphor Powder in Potassium Silicate and Potassium Silicate-Barium Acetate Settling Media

J. F. Hazel and Louis Fiorito, Dept. of Chemistry, University of Pennsylvania, Philadelphia, Pa.

A zinc sulfide-zinc cadmium sulfide phosphor was settled through aqueous solutions used in the preparation of cathode ray screens under conditions where the volume of the settled powder could be measured. The volume was decreased by low concentration of potassium silicate. The volume passed through a minimum and then increased as the concentration of silicate was increased. The presence of barium acetate in mixtures with potassium silicate increased the volume. A correlation exists between the sedimentation volume and zeta potential of the particles.

Abstract No. 95

Surface Phenomena Associated with the Application of Organic Films to Phosphor Screens

R. W. Dudding, Research Labs., General Electric Co. Ltd., Wembley, Middlesex, England

The production of aluminized screens for cathode ray tubes involves the formation of a temporary organic barrier film on the phosphor coating upon which the Al may be deposited. Defects in this film produce undesirable blemishes on the finished screen. Certain inherent defects encountered when employing a "flow" filming technique are described and the fundamental factors governing their formation and prevention are considered.

Abstract No. 96

Photodeposition of Luminescent Screens

M. Sadowsky and D. Payne, Jr., Philco Corp., Lansdale, Pa.

A description of the processes employed by the Philco Corp. in photodepositing a striped phosphor screen for color television is given. Some theories of chemical mechanisms involved in this deposition are presented. The relative importance of various parameters in the deposition is discussed.

Abstract No. 97

Phosphor Slurry Process for Color Kinescope Screening

D. J. Donahue and T. A. Saulnier, Tube Div., Radio Corp. of America, Lancaster, Pa.

In the preparation of the screen for a shadow-mask color kinescope, phosphor powders are dispersed in a photosensitive binder to form slurries. The phosphor slurries are then applied to tube assemblies by means of a spinning technique. This paper outlines general methods of preparation of the photosensitive slurries, and discusses process steps from slurry application through exposure, development, and inspection.

ELECTROTHERMICS AND METALLURGY

Abstract No. 98

High Temperature Oxidation of High Purity Nickel between 750° and 1050°C

E. A. Gulbransen and K. F. Andrew, Westinghouse Research Labs., Churchill Borough, Pittsburgh 35, Pa.

Kinetic studies have been extended to 1050°C to determine the conditions and mechanism of breakdown of the metal in oxidation. Below 900°C the metal oxidizes in the normal manner and rate data fit in well with rate relationships already established. At 900°C and higher, parabolic rate law plots of the data show increasing values of the constants with time. At 1000°C and higher, the oxide cracks away from the metal. It is suggested that nickel fails in oxidation due to a breakdown in the adhesion at the oxide-metal interface.

Abstract No. 99

Ten-Gram Levitation Melted Ingots

G. Comenetz and J. W. Salatka, Westinghouse Research Labs., Churchill Borough, Pittsburgh 35, Pa.

An account is given of experience at levitation melting and casting ingots of a number of pure metals and alloys, weighing from 6 to 13 g. The apparatus is similar to that of Polonis, Butters, and Parr. The technique seems likely to become widely used.

Abstract No. 100

Growth of Whiskers by Reduction of Halogenides

H. Wiedersich, Westinghouse Research Labs., Churchill Borough, Pittsburgh 35, Pa.

Reduction of halogenides results in a variety of growth forms of the precipitated crystals. The main forms observed are roughly equiaxed crystals with low indexed faces and "whiskers", i.e., long, thin crystals. Thermodynamic and kinetic considerations are applied to the variables which could influence the growth forms and checked with experimental results. Strong indications are found that an adsorption phenomenon makes certain crystallographic faces

growth-inactive and causes whisker growth.

Abstract No. 101

Zone Melting of Uranium

C. I. Whitman, V. Compton, and R. B. Holden, Atomic Energy Div., Sylvania Electric Products Inc., Bayside, N. Y.

A study was made of the possible application of the zone melting technique to the separation of U from fission products and other impurities. Bar specimens of U having various alloying elements were zone purified in thoria-coated alumina boats. Uranium bars previously irradiated in the Brookhaven pile were also zone melted. Although zone melting did not appear promising as a method of processing irradiated U because of slagging of fission products into the surface of the bar, this technique has potential application to removing such fission products as Zr, Nb, and Ru, and to purifying ordinary U from such impurities as B, Fe, Si, Ni, and Co.

Abstract No. 102

Molybdenum Plating Inside of Large Bore Tubes

P. L. Raymond, National Research Corp., Cambridge, Mass.

The high temperature reduction of molybdenum pentachloride by H was used to deposit high purity Mo plates inside of large bore tubes. A large number of plating runs were conducted to develop the equipment and procedures and to determine the optimum operating condition. Strong adherent plates of Mo 0.004 in. thick were deposited inside of tubes utilizing equipment constructed from common engineering materials and components.

Abstract No. 103

Influence of Crystal Face on Some Electrochemical Properties of Single Crystals of Copper

A. T. Gwathmey, Dept. of Chemistry, University of Virginia, Charlottesville, Va.

Single crystals of Cu were etched in solutions of copper sulfate-H_2SO, and it was found that etching characteristics of the different faces varied with the *p*H of the solution. Measurements were made of the electrochemical potentials of the different faces in solutions of copper sul-

fate, and the effect on the potentials of annealing the crystals, of the nature of the gas dissolved in the solution, and of the pH of the solution was investigated.

Abstract No. 104

Structural and Chemical Factors Associated with the Fracture of Metals

W. D. Robertson, Hammond Metallurgical Lab., Yale University, New Haven, Conn.

Different crystal and intercrystalline imperfections are considered with respect to their role in fracture. The chemical activity of the metallic structure in the vicinity of these imperfections is discussed with respect to its significance in initiating fracture at particular structural sites.

Abstract No. 105

Influence of Structural Factors on the Corrosion of Stainless Steel

N. A. Nielsen and M. A. Streicher, Engineering Research Lab., Engineering Dept., E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.

As a group, stainless steels exhibit a wide variety of corrosion phenomena which are known to be structure-dependent. Passivity, intergranular corrosion, and pitting-corrosion behavior are discussed in terms of such factors as alloy grain size and orientation, cold work, secondary-phase distribution, corrosive medium, etc., which affect the type, intensity, and localization of corrosion. These effects are demonstrated by weight loss and corrosion-rate data as well as by micrographic studies of corroded stainless steel samples.

Abstract No. 106

Role of Metal and Oxide Structures in High Temperature Oxidation Processes

C. E. Birchenall, Forrestal Research Center, Princeton University, Princeton, N. J.

The course of high temperature oxidation reactions of metals and alloys depends on the inherent properties of the metal phase and the oxide products and also on the relative values of some properties for two or more phases. Although the relative properties are most clearly associated with the early stages,

especially nucleation, they play an important role in determining the soundness of the oxide layer and the metal-oxide interface in later stages of the reaction.

Abstract No. 107

Effect of Dislocations in Oxide Films on Oxidation

N. Cabrera, Dept. of Physics, University of Virginia, Charlottesville, Va.

(No abstract received)

Abstract No. 108

Interaction of Oxide and Metal Crystal Structures*

J. T. Waber, Los Alamos Scientific Lab., University of California, Los Alamos, N. Mex.

The general problem of the epitaxy of oriented overgrowths and, in particular, the relation of oxide films to their parent metals is reviewed. Wilman's theory is used to explain the lack of an orientation relationship between UO_2 and U even though the UO_2 film has been demonstrated to be oriented with respect to the specimen surface. The scant evidence which suggests that the surface orientation may depend on external conditions during oxidation is presented.

* Work done under the auspices of the Atomic Energy Commission.

Abstract No. 109

The Element Columbium and Its Compounds

J. R. Darnell and L. F. Yntema, Fansteel Metallurgical Corp., 2200 Sheldon Rd., North Chicago, Ill.

Columbium, a member of Group V of the Periodic Table, is a high melting metal whose compounds are in general nonbasic in character. It forms refractory binary compounds with elements of Groups III, IV, and V. Its melting point and reactivity impose restrictions on methods of preparation. The metal is of particular interest as a high temperature material of construction because of its strength at high temperatures and its workability.

Abstract No. 110

Supplies of Columbium

K. B. Higbie, Bureau of Mines, U. S. Dept. of the Interior, Washington 25, D. C.

(No abstract received)

Abstract No. 111

Some Sources and Production Statistics for Columbium

H. P. Croft, Kennecott Sales Corp., 161 E. 42 St., New York 17, N. Y.

(No abstract received)

Abstract No. 112

Economic Aspects and Supply Situation for Columbium

R. L. Carmichael, Battelle Memorial Institute, Columbus 1, Ohio

(No abstract received)

Abstract No. 113

A Review of the Extractive Metallurgy of Niobium

M. E. Sibert, A. J. Kolk, and M. A. Steinberg, Horizons Inc., 2905 E. 79 St., Cleveland 4, Ohio

Preparation of Nb metal has been attempted by a number of chemical and electrochemical routes. The chemical reduction of Nb compounds such as Nb_2O_5, K_2NbOF_5, K_2NbF_7, and $NbCl_5$ has been conducted with varying degrees of success. The electrochemical reduction of Nb from aqueous baths has been attempted, but no aqueous bath has been found to produce bulk deposits of metal. The electrolysis of molten baths containing K_2NbOF_5 or K_2NbF_7 has produced Nb metal.

The more promising methods of preparation of Nb metal at the present time include the reaction of Nb_2O_5 and NbC or C, hydrogen reduction of $NbCl_5$, and electrolysis of K_2NbF_7-NaCl mixtures.

Abstract No. 114

Informal Comments on the ONR Program of Basic Research on Columbium

N. E. Promisel, Materials Branch, Bureau of Aeronautics, Navy Dept., Washington 25, D. C.

(No abstract received)

Abstract No. 115

Separation of Ta and Nb

J. L. Tews and S. L. May, Bureau of Mines, U. S. Dept. of the Interior, Albany, Ore.

(No abstract received)

Abstract No. 116

Preparation and Properties of High Purity Tantalum and Columbium

R. C. Bourke, J. M. Blocher, Jr., and I. E. Campbell, Battelle Memorial Institute, Columbus 1, Ohio

(No abstract received)

Abstract No. 117

Preparation of High Purity, Ductile Niobium Metal by Fusion Electrolysis

A. J. Kolk, M. E. Sibert, and M. A. Steinberg, Horizons Inc., 2905 E. 79 St., Cleveland 4, Ohio

Electrolysis of molten solutions of K_2NbF_7 in NaCl and in NaCl-KCl mixtures has been conducted on a laboratory scale. The investigation has been conducted in a range of compositions of 10–40 w/o K_2NbF_7. The temperature range which was investigated in the case of K_2NbF_7-NaCl mixtures was 785°–840°C. Electrolysis of solutions of K_2NbF_7 in NaCl-KCl mixtures was conducted in the range of 675°–740°C. High purity, ductile niobium metal was prepared by the electrolytic procedure throughout a wide range of operating conditions.

Abstract No. 118

Analysis of Certain Metallic Impurities in Niobium

J. F. Reed and A. H. Wolfe, Research Labs., Westinghouse Electric Corp., Beulah Rd., Churchill Borough, Pittsburgh 35, Pa.

Procedure, accuracy, and precision of methods for the determination of certain metallic impurities in niobium are discussed.

Abstract No. 119

Analysis of Oxygen and Nitrogen in Niobium

W. Harris, Research Labs., Westinghouse Electric Corp., Beulah Rd., Churchill Borough, Pittsburgh 35, Pa.

Procedure, accuracy, and precision of methods for the determination of oxygen and N in Nb are discussed.

Abstract No. 120

Hydrogen and Niobium—Reaction and Diffusion Kinetics

M. W. Mallett and W. M. Albrecht, Battelle Memorial Institute, Columbus 1, Ohio

The reaction of H with Nb has been studied at 200°–700°C principally at 1 atm pressure. The pressure dependency of the reaction was investigated. Diffusion and solubility data were also obtained in the same temperature range. A reaction mechanism is proposed.

Abstract No. 121

Tensile Properties of Niobium on the Basis of Purity and Prior Stress History

F. J. Anders, Jr., and W. I. Pollock, Pigments Dept., E. I. du Pont de Nemours & Co., Newport, Del.

Tensile tests on samples of pure Nb have been conducted at room temperature. Rolling textures for Nb sheet have also been investigated. A behavior similar to α-iron in both tensile tests and rolling texture is observed. The effect of impurities is demonstrated to some extent.

Abstract No. 122

Ductile-to-Brittle Transition in Niobium

E. T. Wessel and D. D. Lawthers, Research Labs., Westinghouse Electric Corp., Beulah Rd., Churchill Borough, Pittsburgh 35, Pa.

Flow and fracture characteristics of commercially pure Nb are determined for the case of simple tension. The influence of such variables as temperature, strain rate, chemistry, and microstructure on the transition behavior are described.

Abstract No. 123

Effect of Rare Earth Additions on the Ductility of Arc-Melted Group V-A Metals

J. W. Semmel, Jr., Metallurgy and Ceramics Research Dept., General Electric Co., The Knolls, Schenectady, N. Y.

Semipure metals of Group V-A V, Nb, and Ta were arc melted with rare earth additions, producing relatively soft buttons which were cold rolled successfully. Under similar conditions, but

without the rare earth addition, these metals were harder and could not be cold rolled. A hot forged and cold rolled Nb-Ce alloy had room temperature and 2000°F tensile properties comparable to those of commercial Nb, which is made ductile by vacuum sintering. It is difficult to obtain sound buttons and the best ductility in Nb on the first melting.

Abstract No. 124

Electroplating on Columbium

J. G. Beach, Battelle Memorial Institute, Columbus 1, Ohio

Electroplated metals on Cb are an aid to joining Cb to another metal. Cb can be electroplated with Fe with a fair degree of adhesion. Subsequent outgassing at 400°F and heat treatment at 1300°F results in excellent adherence of the Fe coating. This Fe coated Cb then can be plated with other metals or joined to other metals by conventional means.

Abstract No. 125

Oxidation of Niobium between 375° and 700°C

E. A. Gulbransen and K. F. Andrew, Research Labs., Westinghouse Electric Corp., Beulah Rd., Churchill Borough, Pittsburgh 35, Pa.

Nb has been found to oxidize in a complex manner. At 400°C and lower a slow rate of reaction is observed with the kinetics following the parabolic rate law. At a weight gain of 55–70 $\mu g/cm^2$ a transition in the kinetics occurs to a nearly linear rate law. Between 550° and 625°C the oxidation rate is nearly constant as a function of temperature, while above 625°C the oxidation rate again increases with the temperature. The adherence of the oxide is poor above the transition point.

Abstract No. 126

Development of Oxidation-Resistant Niobium Alloys

H. T. Kling, Atomic Energy Div., Sylvania Electric Products Inc., Bayside, N. Y.

The nature of the oxidation process in pure Nb in described. The effect of the addition of several alloying elements on the oxidation process is then discussed in detail.

Abstract No. 127

Effect of Alloy Additions on Oxidation Resistance of Niobium

F. J. Clauss and C. A. Barrett, NACA Lewis Flight Propulsion Lab., 21000 Brookpark Rd., Cleveland 11, Ohio

Selection of alloying elements for improving the oxidation resistance of Nb at elevated temperatures is discussed. Results are presented of an extensive survey to evaluate the effects of up to 25 at. % of various alloying additions on the oxidation behavior at 1000° and 1200°C.

Abstract No. 128

Oxidation of Niobium-Chromium Alloys at Elevated Temperatures

C. A. Barrett and F. J. Clauss, NACA Lewis Flight Propulsion Lab., 21000 Brookpark Rd., Cleveland 11, Ohio

Detailed studies of the kinetics and mechanisms of oxidation of Nb-Cr alloys are presented. Results include continuous oxidation curves, x-ray diffraction studies, microstructural examinations, and chemical analyses of the scales and alloys.

Abstract No. 129

Vacuum Reactions of Niobium during Sintering

W. D. Klopp, C. T. Sims, and R. I. Jaffee, Battelle Memorial Institute, Columbus 1, Ohio

(No abstract received)

INDUSTRIAL ELECTROLYTIC

Abstract No. 130

Electromagnetic Forces in a Large Aluminum Furnace

O. Chr. Böckman, Elektrokemisk A/S, Oslo, Norway, and J. Wleügel, A/S Norsk Aluminium Co., Oslo, Norway

Certain difficulties in the operation of large Al furnaces are known to be caused by electromagnetic forces set up in the molten cryolite and Al layers. The problem has been analyzed mathematically and by use of scale models. Results obtained by this analysis and possible ways of reducing the electromagnetic forces are surveyed.

Abstract No. 131

Electrical Conductivity of Molten Florides, I. Apparatus and Method

E. W. Yim and Morris Feinleib, Chemical Research Dept., Kaiser Aluminum & Chemical Corp., Permanente, Calif.

A method and apparatus have been developed for determining the electrical conductivity of cryolite-base melts and other fluorides. Hot-pressed BN is used to fabricate high-resistance cells with constants ranging from 17 to 39 cm^{-1}. Such cells must be used under an inert atmosphere. Furthermore, in order to correct for the conductance of the cell body proper, measurements have to be made with the cell immersed in melt as well as out of the melt. A furnace and apparatus for accomplishing these objectives are described. An a-c Wheatstone bridge is used for measurements. Although Inconel electrodes were employed, resistance values were found to be independent of frequency above 1000 cycles.

Abstract No. 132

Electrical Conductivity of Molten Fluorides, II. Conductance of Alkali Fluorides, Cryolites, and Cryolite-Base Melts

E. W. Yim and Morris Feinleib, Chemical Research Dept., Kaiser Aluminum & Chemical Corp., Permanente, Calif.

The electrical conductivities of molten LiF, NaF, KF, Li_3AlF_6, Na_3AlF_6, and K_3AlF_6 have been determined. Typical values are:

Salt	LiF	NaF	KF
Temp, °C	900	1020	900
K, ohm^{-1} cm^{-1}	8.43	5.15	3.80
Salt	**Li_3AlF_6**	**Na_3AlF_6**	**K_3AlF_6**
Temp, °C	900	1020	1020
K, ohm^{-1} cm^{-1}	3.78	2.84	2.28

The effect of alumina, CaF_2, and $NaF:AlF_3$ ratio on the conductivity of cryolite-base melts has been studied. Molar and equivalent conductances have been calculated for several melts, and their significance is discussed.

Abstract No. 133

Uranium Metal Preparation by Electrolytic Reduction of Its Oxides

L. W. Niedrach and B. E. Dearing, Knolls Atomic Power Lab., General Electric Co., Schenectady, N. Y.

Background work is described for a new continuous process for production of U by electrolytic reduction of U oxides in fused salt electrolytes. Unlike past electrolytic processes for U production, the present one is operated at temperatures (1200°–1250°C) above the melting point of U. The effect of current, salt bath composition, and other variables on efficiency and cell operation are discussed. Advantages of the new process are outlined, and areas requiring additional development work are indicated.

Abstract No. 134

Chlor-Alkali Committee Report

J. C. Cole, Diamond Alkali Co., Union Commerce Bldg., Cleveland 14, Ohio

(No abstract received)

Abstract No. 135

Influence of Impurities in the Electrolyte in Chlorine-Caustic Electrolysis by the Mercury Cell Process, VI. Investigation of the Influence of Graphite Particles on Amalgam Decomposition and Cathodic Current Efficiency

Gösta Angel, Rolf Brännland, and Stig Dahlerus, Div. of Applied Electrochemistry, Royal Institute of Technology, Stockholm, Sweden

The influence of graphite particles on the Hg cell process for the production of Cl and caustic soda has been investigated by measuring decomposition rate of sodium amalgam in buffered NaCl solutions and by study of the current efficiency of a laboratory mercury cell. Quantities of graphite under 3 g/l have little effect on current efficiency with pure brine, but in the presence of Mg or Al the effect is appreciable. The simultaneous presence of graphite and either Fe, Ca, or small quantities of V (<0.1 mg/l) does not affect the electrolysis process. Silicates and stannates inhibit the action of the graphite particles.

Abstract No. 136

The Castner-Kellner Shunt Circuit for Mercury Chlor-Alkali Cells

M. Janes, National Carbon Research Labs., National Carbon Co., A Div. of Union Carbide and Carbon Corp., Cleveland, Ohio

Analysis of the Castner-Kellner shunt circuit by Kirchoff's laws shows that anodic concentration polarization in the amalgam decomposition cell is a result of the circuit arrangement, and not the primary cause, as has been stated, of the failure to attain appreciable utilization of the chemical energy of the decomposition reaction as electrical energy (voltage saving). The potential of the anode in the denuder cell determines the Na concentration in the Hg returned to the Cl cell. The variation of this potential with other operating factors is discussed. An estimate is made of the possible voltage saving if some expedient other than the shunt circuit were employed to maintain a Na balance.

Abstract No. 137

Electrolytic Production of Sodium Perchlorate Using Lead Dioxide Anodes

J. C. Schumacher, D. R. Stern, and P. R. Graham, American Potash & Chemical Corp., Whittier, Calif.

The purpose of this study was to investigate the use of lead dioxide anodes as a substitute for Pt in the production of $NaClO_4$. Rod shaped lead dioxide deposits were prepared by plating on wires. Lead dioxide anodes will produce $NaClO_4$ at high cumulative current efficiencies. One anode was used 3000 hr. $NaClO_4$ can be produced using various metallic cathodes. Energy results indicate that stainless steel and Ni are the best cathodic materials. NH_4ClO_4 prepared from the $NaClO_4$ produced in this investigation contained no significant metallic contamination.

THEORETICAL ELECTROCHEMISTRY

Abstract No. 138

Interpretation of Activity and Osmotic Coefficients

George Scatchard, Dept. of Chemistry, Massachusetts Institute of Technology, Cambridge, Mass.

The Debye discharge-transfer-charge process in continuous media gives a start toward interpreting the cumulative, and approximately additive, effects of the charge-charge, charge-molecule, and molecule-molecule interactions in electrolyte solutions. For noble gas-type ions in water, the latter two are approximately those of holes in the solvent. The next approximations include effects on deviations from additivity, "higher terms," structure of the solvent, and specific deviations from noble gas-type ions. The greatest difficulties arise from those effects which are also operative in aqueous solutions of nonpolar electrolytes.

Abstract No. 139

Electrolytic Solution Problem in Statistical Mechanics

J. E. Mayer, Enrico Fermi Institute for Nuclear Studies, University of Chicago, Chicago, Ill.

The treatment of liquid solutions by formal statistical mechanical methods is always plagued by the absence of a completely satisfactory treatment of even a pure liquid. However, to some extent this difficulty can be evaded by assuming a knowledge of the properties of the pure solvent at the outset of the treatment. Various tricks for doing this are available. For electrolytic solutions, a special problem, the long range of the forces and consequent nonconvergence of the ordinary methods, adds a complication. Again, methods of avoiding the difficulty are available.

Abstract No. 140

Successes and Limitations of the Theory of Debye and Hückel

E. A. Guggenheim, Dept. of Chemistry, University of Reading, Reading, England

Appraisal of the Debye-Hückel theory should distinguish between the model (complete ionization, rigid spherical ions) and the approximation ($z\,e\,\psi \ll kT$). For 2-2 electrolytes in water the model is valid, the approximation is not. A combination of Müller's more accurate solution with a modified form of Bjerrum's conventional definition of association leads to complete agreement between theory and experimental measurements of freezing points on six sulfates of bival-

ent metals which are shown to have effective mean diameters between 3.5 and 4.0 A.

Abstract No. 141

Statistical Mechanical Theory of Plasmas and Liquid Metals

J. G. Kirkwood, Sterling Chemistry Lab., Yale University, New Haven, Conn.

The Fermi-Thomas statistical theory of the atom and the Debye-Hückel theory of strong electrolytes are combined to provide a statistical mechanical description of electroneutral systems of positive ions and electrons in thermodynamic equilibrium. Differential equations for the average electrostatic potentials in the neighborhood positive ions and electrons are formulated, and the electrostatic free energy and equation of state of a dilute plasma are calculated. A generalization of the theory to include liquid metals is outlined.

Abstract No. 142

Properties of Concentrated Solutions of Acids and Alkalies

R. P. Bell, Physical Chemical Labs., Balliol College, Oxford, England

Data are presented for the acidity functions of a number of acids in aqueous solution over a large concentration range. Some analogous results are given for concentrated solutions of alkalies. Suggestions are made as to the interpretation of these results with special reference to the structure of water and of the hydrogen ion and the possible polymerization of the acid anions.

Abstract No. 142A

Present State of the Electrolyte Problem

C. A. Kraus, Dept. of Chemistry, Brown University, Providence, R. I.

This paper is a summarizing outline of present electrolyte problems.

Abstract No. 143

Properties of Rare Earth Salts in Electrolytic Solutions

F. H. Spedding and Gordon Atkinson, Institute for Atomic Research, Iowa

State College of Agriculture and Mechanic Arts, Ames, Iowa

For the past eight years, the Ames Lab. has had a program of studying the electrolytic properties of the rare earth salts. These studies cover solutions of the chlorides, bromides, nitrates, perchlorates, and sulfates of the rare earth series. Data on the activity coefficients, conductances, transference numbers, heats of solution, heats of dilution, partial molal volumes, and partial compressibilities have been assembled in one paper. These data are discussed with respect to the Debye-Hückel and Onsager theoretical predictions. Regularities which have been observed are emphasized.

Abstract No. 144

Nuclear Magnetic Resonance Studies of Aqueous Solutions*

H. S. Gutowsky, Noyes Chemical Lab., University of Illinois, Urbana, Ill.

Very small interactions produce readily detectable changes in the various characteristics of the nuclear magnetic resonance absorption of a sample. Therefore, it is to be expected that intermolecular or interionic interactions can be studied by observing their effects on absorption. The nmr principles involved are summarized. Earlier nmr studies of solutions are reviewed and some recent work at Illinois is described. These applications include: (*a*) chemical shifts and quadruple broadening which are associated with the structure of solutions; (*b*) the study of rate processes in solution under equilibrium conditions by spin-lattice relaxation time measurements and also by chemical shifts.

* Assisted in part by ONR.

Abstract No. 145

Raman Spectral Studies of Ionic Equilibria in Solutions of Strong Electrolytes

T. F. Young, Dept. of Chemistry, University of Chicago, Chicago, Ill.

Some electrolytes emit Raman spectra sufficiently intense and simple to permit accurate (photoelectric) determinations of ion concentration. Measurements of intensities combined with studies of other properties, e.g., nuclear magnetic

resonance and conductance, yield equilibrium constants covering temperature ranges so wide (150°–300°C) that $\Delta \bar{C}_p^0$ can be estimated. Values for the dissociation of strong acids are similar to those for typical weak acid (−35 to −40 cal mole^{-1} deg^{-1}).

Several nonaqueous solutions have been studied. Of particular interest are mixtures of fused salts, e.g., KCl and $CdCl_2$, in which complexes similar to those in aqueous media are observed.

Abstract No. 146

Melting Mechanisms of Ionic Crystals

A. R. Ubbelohde, Dept. of Chemical Engineering, Imperial College of Science and Technology, London, England

Mechanisms of melting which involve primarily positional disorder of the ions are reviewed. Normally these are not accompanied by extensive premelting in the solid state; some interesting exceptions are considered. Other melting mechanisms may accompany positional disorder in certain ionic salts. For polyatomic ions, formation of association complexes on melting can make important contributions to the total entropy of fusion, and can lead to abnormally low melting points.

Abstract No. 147

Influence of Complex Ions on Structure and Reactivity of Fused Salts

E. R. VanArtsdalen, Oak Ridge National Lab., Oak Ridge, Tenn., and National Carbon Research Labs., Cleveland, Ohio

Evidence for the existence of various types of complex ions in fused salts is presented and reviewed for both single salts and mixtures. Certain important structural concepts are considered. Methods and results are discussed which have been obtained by measurement of such properties as freezing point depression, entropy of fusion, viscosity, electrical conductance, x-ray diffraction, and reaction rate. Examples are given to illustrate ways in which the kinetics of chemical reactions, including electrode processes, can be influenced by the presence of complexing agents in a melt.

Abstract No. 148

A Point of View on Ion Clouds; A Suggested Explanation of an Activity Anomaly in Dilute Aqueous LiCl Solutions

H. S. Frank and P. T. Thompson, Dept. of Chemistry, University of Pittsburgh, Pittsburgh, Pa.

The log $\gamma - m^{1/2}$ curve for aqueous LiCl has a break near 0.001M which is so sharp that some cooperative phenomenon seems to be involved. It is suggested that in addition to a special ion-water structure effect there is a quasi-transition from the Debye-Hückel type ion cloud to a "diffuse lattice" type, in keeping with the accurate $m^{1/2}$ dependence of log γ from 0.001M to 0.05M. Theoretical considerations and the shapes of many activity, conductance, and diffusion curves suggest that such a lattice cloud occurs rather generally.

Abstract No. 149

Incomplete Dissociation in Aqueous Salt Solutions

C. W. Davies, Edward Davies Chemical Labs., University College of Wales, Aberystwyth, Wales, Great Britain

Development of methods for estimating the proportion of free ions in an aqueous electrolyte solution is described. Some of the results obtained are reviewed with reference to Bjerrum's ion-association hypothesis and to ionic hydration theories.

Abstract No. 150

Hydration and Association in Aqueous Electrolyte Solutions

E. Glueckauf, Atomic Energy Research Establishment, Harwell, Berks., England

Various approaches to effects of ionic hydration, hydrated ion size, and ionic association are examined critically. For weak ion pair formation, effectively linear terms result which cannot be separated from other terms. However, from strong associations (e.g., 2:2 electrolytes) nonlinear functions arise. Thus for $MgSO_4$ solutions Brown and Prue have shown that osmotic data up to 0.03M indicate formation of the undissociated ion pair. This paper shows that, up to 1M, data are consistent with additional formation of the triplet ion

$Mg(SO_4)_2^{2-}$, but not with the complex $Mg(SO_4)_2$. This seems to apply to all 2:2 electrolytes.

Abstract No. 151

Hydrogen Bond Structures, Hydration of Protons, and Proton Transfer in Aqueous Solutions

M. Eigen, Max-Planck Institute for Physical Chemistry, University of Göttingen, Göttingen, Germany

From thermodynamic and kinetic data a defined model for hydration of the proton in aqueous solution has been derived. According to this model the proton exists as H_3O^+ ion connected to at least three additional H_2O molecules by H bonds, forming a complex with a proton of excessive mobility. Relaxation measurements in pure water and ice result in a half-life of about 10^{-12} –10^{-14} sec for the individual H_3O^+. Measurements with a new "stationary field method" yield an appreciably higher protonic mobility in ice than in water. Such proton-conducting H-bond systems which are also of biological interest show certain parallels to electronic semiconductors.

Abstract No. 152

Quantitative Measurements of Ionic Vibration Potentials*

E. Yeager, J. Booker, and F. Hovorka, Ultrasonic Research Lab., Western Reserve University, Cleveland, Ohio

When ultrasonic waves are introduced into an electrolytic solution, alternating potential differences are produced within the solution. This effect was proposed by Debye in 1933 for the study of ionic hydration. Apparatus involving pulse-modulated waves has been developed specifically for the investigation of this effect. Data with an estimated accuracy of ±10% will be presented and interpreted for several electrolytes at frequencies in the range 10^5 to 10^6 cps.

* Based on research supported by the Office of Naval Research.

Abstract No. 153

A Physical Theory of Ion Solvation

M. Balkanski, Corrosion Lab., Massachusetts Institute of Technology, Cambridge, Mass.

An attempt is made to calculate heat of solvation based on electrostatic considerations. The ion is assumed to be a spherical conductor with a uniform surface charge density enveloped by water molecules of volume v_1. The electrostatic energy accummulated in this volume is calculated, neglecting action of the electrical field of the ion outside the limits of the solvated complex, and expresses variation of solvation energy in which water polarization is assumed due only to dipole orientation. Here, the polarization is given by the Langevin function. Variation of energy is given by integration of this function between the crystallographic radius of the ion and the experimentally determined radius of the complex. The heat of solvation is calculated for certain cases.

Abstract No. 154
Aquo-ions and Ion Pairs

J. F. Duncan and D. L. Kepert, Chemistry Dept., University of Melbourne, Victoria, Australia

The electrostatic model of chemical bonding is discussed in relation to the structure of aquo-ions, complex ions, and ion pairs. Systematic relations between (*a*) the standard thermodynamic quantities of formation, (*b*) those of the components, and (*c*) the ionic radii are interpreted. The evidence on the nature of ion pairs obtainable from spectra is considered with reference to the crystal field theory.

Abstract No. 155
Ionization of the Bisulfate Ion; Notes on the Electromotive Force Method of Determining Ionization Constants

W. J. Hamer, National Bureau of Standards, Washington 25, D. C.

The ionization constant of the bisulfate ion determined by emf and spectrophotometric methods differs by 16% at 25°C. Harned and Owen in their book state "A reexamination of the methods of computing K_{2A} from the electromotive forces may remove this discrepancy." In 1952 Davies appeared to have removed the discrepancy by taking Na_2SO_4 as incompletely dissociated.

This paper gives a re-examination of emf data. Whereas the limiting Debye-Hückel equation was originally used, "ion sizes" were incorporated with

resultant nonconvergence at infinite dilution. This is general for the emf method; nonconvergence is progressively higher with lower *p*Ks. Surprisingly, however, convergence is obtained when salt-free solutions, as employed by Davies, are used.

Abstract No. 156

Heats of Dilution of Very Dilute Solutions of Weak and Strong Electrolytes

E. Lange, Institute of Physical Chemistry, University of Erlangen, Erlangen, Germany

Heats of dilution of dilute aqueous solutions of electrolytes may be caused by interionic forces between dissolved ions and/or by heats of dissociation of dissolved molecules. Very dilute solutions of strong electrolytes show practically only exothermic interionic effects corresponding to their ionic valence type. Weak electrolytes and nonelectrolytes are exothermic or endothermic; in some cases they cause heats of dissociation. In dilute solutions, salts of weak bases or acids show heats of hydrolysis.

Abstract No. 157

Anion Exchange Studies of Metal Complexes

K. A. Kraus, Chemistry Div., Oak Ridge National Lab., Oak Ridge, Tenn.

Anion exchange of metal complexes is a general tool for investigation of complexing properties of metals. The method is of the thermodynamic type and is a supplement to other methods. With a large amount of anion exchange information available, conclusions may be drawn on a comparative basis. In favorable cases, equilibrium quotients for complex equilibria and information regarding the pertinent coefficient ratios may be obtained. The method is relatively simple for dilute electrolyte solutions, and reasonably firm for concentrated electrolyte solutions.

Abstract No. 158

Electrophoresis and Conductivity in Solutions Containing Polyelectrolytes

J. J. Hermans, Lab. for Inorganic and Physical Chemistry, Rijks University, Leiden, The Netherlands

According to a simple theory, the

electrophoretic mobility U of charged chain molecules should be independent of the molecular weight when the ionic strength μ of the solution is high. At lower μ-values, U may increase and eventually reach a maximum. Some data appear to confirm this. It is more difficult to predict the conductivity κ. Experiments show that κ sometimes decreases in cases where the simple theory indicated above predicts an increase. An attempt to explain this behavior in terms of relaxation effects will be discussed.

Abstract No. 159

Normal and Abnormal Ionic Mobilities in Anhydrous Hydrofluoric Acid and Hydrogen Peroxide-Water Systems

Martin Kilpatrick, Dept. of Chemistry, Illinois Institute of Technology, Chicago, Ill.

Abnormal conductances of cations and anions of solvents water and H_2SO_4, and of cations of solvents methyl and ethyl alcohol, have been reported. In liquid ammonia neither the solvent cation nor anion shows abnormal conductance. This paper reports that the cation of anhydrous HF shows no abnormal conductance, but the anion has a higher mobility than other anions.

When H_2O_2 replaces water in a solution of $HClO_4$ the mobility of the cation decreases, and at 99% H_2O_2 the mobility is about the same as that of potassium ion. As H_2O_2 replaces water in a solution of KOH the ratio of the conductance to that of $KClO_4$ first decreases, then passes through a minimum, and increases beyond 25% H_2O_2. This result is interpreted to mean that the hydroperoxide ion has a greater mobility than the hydroxide ion. The problem is also considered for other solvent-water mixtures, and the importance of the nature and structure of the solvent stressed.

Abstract No. 160

Mobilities of Ions and Uncharged Molecules in Solutions in Relation to Viscosity

R. H. Stokes, Dept. of Chemistry, University of New England, Armidale, N.S.W., Australia

The rapid progress being made in the theoretical treatment of interionic effects on the motion of ions in relatively con-

centrated solutions emphasizes the poorness of our present understanding of the relation of viscosity to mobility in such solutions. Data are presented for (*a*) tracer diffusion of iodide in concentrated halide solutions, (*b*) ion mobilities in solutions of aqueous nonelectrolytes, and (*c*) conductances of concentrated electrolytes in water. Attempts are made to correlate the observations with viscosity data.

Abstract No. 161

Conductance Equations of Robinson-Stokes and Wishaw-Stokes Applied to the Regions of Dilute and of Concentrated Solutions, Respectively

A. N. Campbell, Dept. of Chemistry, University of Manitoba, Winnipeg, Man., Canada

This paper deals with the following subjects: the equation of Robinson and Stokes applied to conductance in the region of moderate dilution; limiting conductance of salts which hydrolyze; physical significance of å, the distance of closest approach of the ions; the hydrated ion in aqueous and mixed solvents; application of the Wishaw-Stokes equation to the conductance of concentrated solutions; viscosity correction.

Abstract No. 162

A Redetermination of the Value of the Faraday with the Iodine Coulometer

D. A. MacInnes and A. R. Pray, Rockefeller Institute for Medical Research, New York, N. Y.

Since the most accurate method for determining the charge e on the electron depends on $\mathbf{F} = N e$, the precise value of F takes on new importance, especially as e is related to most other physical constants. Aside from recent research by Craig and Hoffman on the oxalate coulometer, work on evaluation of the Faraday is over 40 years old.

The research described is a return to the iodine coulometer, but using modern techniques. Experimentally, this method depends on finding the amount of iodine released or absorbed during passage of a known current for an accurately measured time. A constant current apparatus has been developed which regulates to at least 1 ppm. The time is obtained from Bureau of Standards broadcasts. Iodine

is determined by differential electrometric titration, with a precision of 1 ppm; titrating fluid is calibrated using iodine tested by activation analysis and other methods.

Abstract No. 163

Diffusion and Activity Coefficients of Electrolytes in Dilute Aqueous Solutions

H. S. Harned, Sterling Chemistry Lab., Yale University, New Haven, Conn.

The theory of diffusion coefficients of electrolytes in dilute solutions leads to the expression

$$D = \nu 1000RT(\tilde{M}/C)\left(1 + C\frac{\partial \ln y_{\pm}}{\partial C}\right)$$

where $\tilde{M}/C$ is a mobility term, and the parenthesis containing the activity coefficient, $y_{\pm}$, is a thermodynamic term. It has been shown by a conductometric method that diffusion coefficients of many electrolytes of different valence types at concentrations below 0.01M conform to the theory. The small variation of the mobility term with concentration, caused by electrophoresis, appears to be of the right sign and magnitude.

Assuming that this mobility term is correct, activity coefficients in dilute solutions can be computed from diffusion data. This method is described and applied to solutions of 15 electrolytes.

Abstract No. 164

Thermal Diffusion and Related Effects in Solutions of Electrolytes

J. N. Agar, Dept. of Physical Chemistry, Cambridge University, Cambridge, England

The thermodynamic treatment of nonisothermal systems is summarized, and the significance of the entropy of transport and "transported entropy" outlined. Two recently developed methods of measuring Soret coefficients are described; they utilize (*a*) changes in emf of a nonisothermal cell, and (*b*) changes in conductance of the solution. The latter appears promising as a general method for dilute solutions of electrolytes. Soret coefficients (or entropies of transport) of aqueous ions are strongly temperature dependent and do not appear to be correlated in any simple manner with other ionic properties.

Abstract No. 165

Temperature Dependence of the Thermal Diffusion of Aqueous KCl

J. G. Longsworth, Rockefeller Institute for Medical Research, New York, N. Y.

Soret coefficients of 1,2,3, and 4*M* solutions of aqueous KCl have been determined over the temperature interval from 10° to 50° in 10° steps. Except at the highest temperature, T, and concentration, m, the magnitude of the coefficient increases as both T and m increase, the salt migrating to the cold plate in each instance. Concentration profiles have been determined *in situ* with the aid of a two-channel cell, filled with solution and solvent, respectively, and Rayleigh interferometry. Results are considered in relation to other methods for the measurement of thermal diffusion in liquids and the emf of electrolytic thermal cells.

Abstract No. 166

Data for the Concentration Dependence of the Four Diffusion Coefficients of the System NaCl-KCl-H_2O at 25°

I. J. O'Donnell and L. J. Gosting, University of Wisconsin, Madison, Wis.

Solute flows J_1 and J_2 in a 3-component system may be related to concentration gradients by the equations

$$J_1 = -D_{11}\frac{\partial C_1}{\partial x} - D_{12}\frac{\partial C_2}{\partial x}$$

$$J_2 = -D_{21}\frac{\partial C_1}{\partial x} - D_{22}\frac{\partial C_2}{\partial x}$$

In general, diffusion coefficients defined by these relations vary with both solute concentrations. Using the Gouy diffusiometer to study the refractive index curves for free diffusion, values have been obtained for the four diffusion coefficients of the system NaCl-KCl-H_2O. Results are reported for the four combinations of the two salt concentrations used, these concentrations being 0.25 and 0.5 mole/l. To evaluate diffusion coefficients for each combination of concentrations, four experiments were performed with different refractive fractions of NaCl. The Gouy fringe deviation graphs, used in evaluation of

the diffusion coefficients, give on inspection direct information about flow interactions.

Abstract No. 167

Thermodynamic Functions of Single Ionic Species in Solutions

Pierre Van Rysselberghe, Dept. of Chemistry, Stanford University, Stanford, Calif.

Current conventions concerning the assignment of absolute values to the free enthalpies, enthalpies and entropies of single ionic species in solutions are critically re-examined. Expressions for absolute electrode potentials and electromotive forces of cells and for their temperature coefficients are written explicitly before conventions are introduced. The treatment, based mostly on a logical elaboration of the original convention concerning the standard hydrogen electrode, avoids contradictions, and is presented as a fundamental adjunct to theories of electrolytes.

Abstract No. 168

Some Thermodynamic Properties of Solutions of Salts of Bivalent Metals

J. M. Austin, R. A. Matheson, and H. N. Parton, Chemistry Dept., University of Otago, Dunedin, New Zealand

The heats of mixing of lead perchlorate and potassium halide solutions have been measured in a microcalorimeter, and the heats of formation of PbX^+ ions derived. Association constants of the ions $CdBr^+$, CdI^+, $Pb(SCN)^+$, $Hg(NO_3)^+$ have been measured spectrophotometrically. The optical method suggests that the ions $Cd(NO_3)^+$, $Cd(SCN)^+$, $Zn(SCN)^+$, PbF^+ do not exist in significant amounts in the solutions studied. The thermodynamics of ion association is discussed.

Abstract No. 169

Ionization Constants of Weak Acids from Spectrophotometric Measurements

R. A. Robinson, Dept. of Chemistry, University of Malaya, Singapore, Malaya

Many acids (including acids of the

anilinium ion type) have markedly different u.v. absorption in solutions of low and high *p*H, and, from the variation of optical density with *p*H at a given wave length, the degree of dissociation and the ionization constant of the acid can be determined. At least three measurements at different *p*H values are needed for a monobasic acid and at least five for a dibasic acid with overlapping dissociation. Recent work on substituted anilines, phenols, and barbituric acids will be discussed with relation to Hammett's Rule.

Abstract No. 170

Conductance and *p*H Measurements in Methanol-Water Mixtures

Theodore Shedlovsky, Rockefeller Institute for Medical Research, York Ave. & 66 St., New York, N. Y.

The electrical conductances of dilute solutions of salts and of strong and weak acids in water-methanol solvent mixtures are compared over the entire range of solvent composition at 25°C. The weak acid ionization constants are computed from these data. They are used for interpreting *p*H types of emf measurements obtained with glass electrodes on buffer solutions in these solvent mixtures.

Abstract No. 171

Ionization Equilibria in Ammonia-Water Solutions from 5° to 55° as Obtained from High Field Conductance Measurements

Emil Arnold, Harlow Freitag, and Andrew Patterson, Jr., Sterling Chemistry Lab., Yale University, New Haven, Conn.

High field conductance measurements on a series of ammonia-water solutions are reported. A temperature range of 5°–55° was covered. High field conductance results are treated so as to obtain ionization equilibrium constants for the several temperatures. Equilibrium constants (in contrast with those obtained from emf measurements) exhibit a minimum at about 30°, where the constant has the value 8.5×10^{-5}. The significance of these results and the possible ionization equilibria in water-ammonia solutions are discussed.

Abstract No. 172

An Isopiestic Unit for High Temperature Studies

B. A. Soldano, R. J. Fox, and R. W. Stoughton, Chemistry Div., Oak Ridge National Lab., operated by Union Carbide Nuclear Co., Oak Ridge, Tenn.

An isopiestic unit has been constructed for aqueous solution work at elevated temperatures up to 150° or higher. Periodic weighing of sample dishes is accomplished inside the vaccum-tight, pressurized, stainless steel equilibration vessel by means of a specially constructed Ti magnetic balance. The unit has been found to operate satisfactorily and to respond more rapidly although less accurately at the higher temperatures. Comparative osmotic coefficients are presented.

Abstract No. 173

Thermodynamics of Hydrogen Chloride in Ethyl Alcohol from EMF Measurements

G. J. Janz and Harry Taniguchi, Dept. of Chemistry, Rensselaer Polytechnic Institute, Troy, N. Y.

EMF measurements of the cell without liquid junction: Pt, H_2(1 atm)| HCl in Ethanol (m)|AgCl-Ag have been carried out at 25°C over a concentration range from 0.0048 to 0.12*M*. New experimental techniques were devised, and the latest computational methods were employed to obtain the standard electrode potential of the Ag, AgCl electrode in anhydrous ethanol and the activity coefficients of HCl in ethanolic solutions at 25°C.

Abstract No. 174

Kinetics of Bromoacetate-Thiosulfate Ionic Reaction

Gerald Corsaro and H. L. Stephens, Dept. of Chemistry, University of Akron, Akron 4, Ohio

Reported results on the kinetics of ionic reactions as between bromoacetate and thiosulfate ions implies a breakdown of the Debye-Hückel theory embodied in the Bronsted-Christionson-Scatchard equations relating salt effects to such reactions. A re-interpretation of the published data with further experimental

results suggests a mechanism for ionic reactions conforming with theory. Ion association and the influence of the dielectric constant of the solvent media on ion association are demonstrated.

Abstract No. 175

Zinc Standard Potential in Water-Organic Mixtures

Gerald Corsaro and H. L. Stephens, Dept. of Chemistry, University of Akron, Akron 4, Ohio

Cell emf measurements with $ZnCl_2$ in EtOH, meOH, and 1,4-dioxane-water mixtures provide extended tests of the Debye-Hückel theory, particularly as it concerns the measured cell potential and the dielectric constant of the solvent. Activity coefficients from observed data compare favorably with those calculated from theory. The measured value for the zinc standard electrode potential is confirmed from the potential-dielectric constant relationship.

Abstract No. 176

Uncommon Valency Ions and the Difference Effect

M. E. Straumanis, Dept. of Metallurgical Engineering, University of Missouri School of Mines and Metallurgy, Rolla, Mo.

The appearance of uncommon ions (on the basis of Faraday's law) in anodic electrolytic processes is sometimes reported in the literature. It is shown that the possibility of formation of such ions could be assumed because the difference effect, the essence of which is explained briefly, was disregarded. Only when the influence of the effect is taken into account, can conclusions be drawn concerning the appearance of uncommon valency ions in anodic processes.

Abstract No. 177

Streaming Potentials in Spherical-Grain Sands

C. E. Bleil (Present address: Research Staff, General Motors Corp., Detroit, Mich.) and Wm. Schriever, Dept. of Physics, University of Oklahoma, Norman, Okla.

Streaming potentials were observed in spherical-grain sands. Water and four

concentrations each of NaI, Na_2SO_4, $MgSO_4$, and $MgCl_2$ were used. The streaming potential per unit pressure V/P was observed to deviate from existing theory and satisfy the following equation

$$V/P = (V/P)_\infty (1 + k/d + k^2/d^2) \exp (-k/d)$$

where $(V/P)_\infty$ is the value for large grain diameter d, and k is a constant.

Abstract No. 178

EDL Capacities at Solid Metal-Solution Interfaces

J. J. McMullen and Norman Hackerman, Dept. of Chemistry, University of Texas, Austin 12, Texas

An electric analog of the metal-solution interface was assumed, and E vs. t changes were deduced mathematically for application of a square wave voltage. Analysis was verified using actual electric components, and it was demonstrated that the component of capacity could be measured readily. The method was then applied with some success to each of the following metals in 1N Na_2SO_4: Hg, Pt, Ag, Cu, Al, and Ta.

Abstract No. 179

Impedence at Polarized Platinum Electrodes in Various Electrolytes

J. N. Sarmousakis and M. J. Prager, William H. Nichols Chemical Lab., New York University, University Heights, New York 53, N. Y.

Results of alternating current bridge measurements of the impedances of bright platinum in contact with 1N aqueous solutions of potassium chloride, potassium bromide, and potassium iodide as functions of polarizing voltage and alternating current frequency are presented. Data may be interpreted in a manner similar to that for experiments with acid solutions. A model is offered to explain, in a qualitative way, the dependence of impedance on frequency for the electrical double layer at rough surfaces.

Abstract No. 180

Catalytic Activity and Electronic Structure

Sigmund Schuldiner and J. P. Hoare, Electrochemistry Branch, Chem-

istry Div., Naval Research Lab., Washington 25, D. C.

Catalytic activity of α- and β-Pd and Au-Pd alloys for hydrogen-producing reactions in solution was determined. A relationship exists between this catalytic activity and heat of adsorption of atomic H. When the atomic combination step is rate-determining, catalytic activity increases as heat of adsorption of atomic H decreases. However, when the slow discharge step is rate-determining, catalytic activity increases as heat of adsorption of atomic H increases. An explanation is given for virtual independence of overvoltage on current density for the H/Pd $\sim$ 1 alloy. Catalytic activity of Au-Pd alloys decreases as Au/Pd atomic ratio increases, indicating that heat of adsorption of atomic H on Au is greater than on β-Pd.

Abstract No. 181

Mechanism of Hydrogen Producing Reactions on Palladium, IV. Electrochemical Kinetics of the α-Palladium-Hydrogen System in Acid Solutions

J. P. Hoare and Sigmund Schuldiner, Electrochemistry Branch, Chemistry Div., Naval Research Lab., Washington 25, D. C.

An experimental investigation of the electrochemical kinetics of the α-palladium-hydrogen system was made by means of a palladium bi-electrode. The *p*H effect on the anodic and cathodic polarization behavior was determined and related to bi-electrode mechanisms. Thickness of the bi-electrode had no significant effect. It was found that catalytic activity for the hydrogen-producing reactions on α-Pd was definitely less than that on β-Pd. The transference number of protons in the bi-electrode was determined. A comparison with a platinum bi-electrode was made.

Abstract No. 182

A Tentative Theory of Inhibitions of Aqueous Kolbe Electrolyses

G. W. Thiessen, Chemistry Dept., Monmouth College, Monmouth, Ill.

Three well-recognized structural interferences exist for the discharge of the ion

$R.COO^-$ at bright Pt anodes in water. They are: (*a*) ethenoid, (*b*) cyclohexanoid, and (*c*) benzenoid, caused by vinyl, cyclohexyl, and phenyl residues in R. Ethenoid inhibition can be correlated with aqueous ionization constants but the others cannot. Ethenoid inhibition appears due to a chain-transmitted electrostatic induction. The others are assumed due to steric hindrance from close carboxylate-ring association at all chain lengths.

Abstract No. 183

Electrochemical Polarization, II. Ferrous-Ferric Electrode Kinetics on Stainless Steel

Milton Stern, Metals Research Lab., Electro Metallurgical Co., a Div. of Union Carbide and Carbon Corp., Niagara Falls, N. Y.

The oxidation-reduction kinetics of the ferrous-ferric sulfate system have been measured on a stainless steel surface. The data completely support theoretical equations which describe the potential-current relationships for such a system. The analysis applies to reversible electrodes and to corroding electrodes where the potential is determined by two intersecting activation overvoltage functions. Also, the analysis permits calculation of a number of electrochemical constants with a minimum number of experimental observations. The possibility of determining anode-to-cathode area ratios for corroding metals is discussed.

Abstract No. 184

Relation between Pitting Corrosion and the Ferrous-Ferric Oxidation-Reduction Kinetics on Passive Surfaces

Milton Stern, Metal Research Lab., Electro Metallurgical Co., a Div. of Union Carbide and Carbon Corp., Niagara Falls, N. Y.

Ferrous-ferric electrode kinetics have been studied on a variety of passive alloys. Activation polarization parameters are not markedly different for all the surfaces studied except for Ti where the exchange current is an order of magnitude smaller. The local anodic polarization curve for solution of metal under passive conditions was found to be

extremely steep. This is suggested as typical behavior for the passive condition.

Abstract No. 185

Potential of an Electrode of a Voltaic Cell. A New Definition with Justification for the Use of Two Sign Conventions

J. B. Ramsey, Dept. of Chemistry, University of California, Los Angeles 24, Calif.

A definition of the potential of an electrode, basically different from that of G. N. Lewis and J. Willard Gibbs, is developed on the basis of a thermodynamic analysis of the conditions existing in an electrode system at equilibrium. The value of this potential, so defined, is shown to be (*a*) invariant in sign, and (*b*) equal in magnitude and opposite in sign to that of the Gibbs potential. A justification for two sign conventions is presented.

Abstract No. 186

The Silver and Thallium Oxide Coulometer

W. T. Foley, Chemistry Dept., St. Francis Xavier University, Antigonish, Nova Scotia

A simple and precise coulometer makes use of a dilute solution of silver and thallium salts buffered to a *p*H of about 9.5 with ammonium nitrate and ammonium hydroxide. The anode deposit is an oxide of thallium and the cathode deposit is an accurate measure of the quantity of electricity used.

Abstract No. 187

Voltammetric Studies at Constant Current in Fused Chlorides

J. M. Wood, Jr., Research and Engineering Dept., Ethyl Corp., P. O. Box 341, Baton Rouge 1, La.

Techniques have been developed for extending the methods of constant current voltammetry to fused chloride solvents at 600°C, and characteristic measurements have been made on several ions. New developments include a new reference electrode, a unique method of separating anode, cathode, and reference compartments, and the development of electrolytic methods for determining hydrogen and oxygen bearing materials in fused halides.

Abstract No. 188

Rates of Oxidation of Titanium in Fused Salt Baths

M. E. Straumanis and Ch. Chiou, Dept. of Metallurgical Engineering, University of Missouri School of Mines and Metallurgy, Rolla, Mo.

Under a layer of molten NaCl, metallic Ti corrodes quickly in the presence of air. It could be shown that the process observed is an oxidation with oxidation products formed of the approximate composition $TiO_{0.2}$. The weight loss-time as well as the rate-temperature relationship was linear, which occurs when oxygen (through the liquid salt layer) and cracks in the Ti-O solid solution coating have free access to the reaction surface. A steady breakdown of the TiO_x solid solution from the surface of Ti was observed, explaining the high rate of oxidation or corrosion. Activation energies of the process were calculated and some conclusions will be drawn in the light of Eyring's theory of rate processes.

Abstract No. 189

Cathode Potentials during the Electrodeposition of Molybdenum Alloys from Aqueous Solutions

D. W. Ernst and M. L. Holt, Dept. of Chemistry, University of Wisconsin, Madison 6, Wis.

Cathode potential measurements were used in an attempt to explain cathode reactions that result in electrodeposition of Mo alloys. Potentials were obtained by the direct method during electrolysis of aqueous ammoniacal citrate solutions containing sodium molybdate, and the sulfate of the codepositing metal, Fe, Ni, or Co. Results indicate that reduction of molybdate ion in presence of a codepositing metal is not accomplished in one step with 6 electrons, but with 1, 2, or 3 electrons depending on the co-metal and its oxidation state. It was also concluded that hydrogen is involved in molybdate reduction. A two-step mechanism for reduction of molybdate ion in presence of a co-metal is proposed and an explanation of why the co-metal must be Fe, Co, or Ni rather than such metals as Cr, Mn, Cu, or Zn is presented.

Abstract No. 190

Electrodeposition of Iron-Molybdenum Alloys

Albertine Krohn and L. O. Case, University of Michigan Ann Arbor, Mich., and N. W. Hovey, University of Toledo, Toledo 6, Ohio

Preliminary experiments indicated that the best Fe-Mo alloy deposits were obtained from solutions containing sodium molybdate, ferric chloride, and sodium pyrophosphate buffered with excess sodium bicarbonate. Efficiency was increased by rotating the cylindrical cathode between rubber wiper blades. A complete study of the variables showed it possible to electrodeposit Fe-Mo alloys which are bright and adherent in thicknesses of a few hundredths of a millimeter. No theoretical treatment is yet available to completely explain this type of codeposition.

FALL MEETING

at the

STATLER HOTEL

Buffalo, N. Y.

October 6, 7, 8, 9, and 10, 1957

Sessions will be scheduled on

Batteries
Corrosion
Electrodeposition (symposium on "Metal Powders")
Electrodeposition — Corrosion (Joint Symposium on "Corrosion of Electrodeposited Metals")
Electronics—Semiconductors
Electro-Organics
Electrothermics and Metallurgy

Abstracts for the Fall Meeting (*not exceeding 75 words in length*) must reach the Secretary's Office, 216 West 102nd Street, New York 25, N. Y., *not later than June 1, 1957* in order to be included in the program.

Indicate on abstract for which Division's symposium the paper is to be scheduled.

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